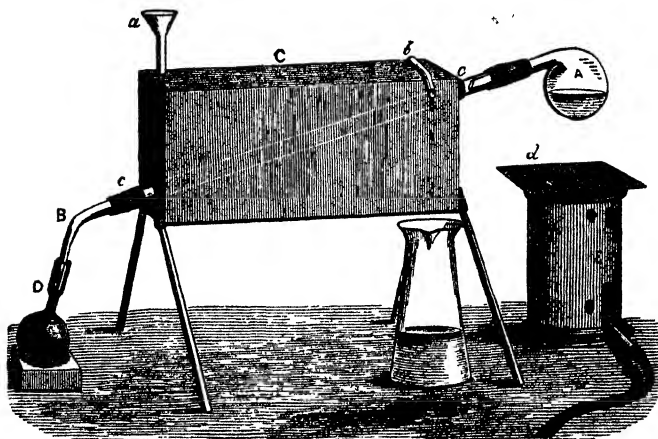


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THE
CHEMICAL TESTING
OF
WINES AND SPIRITS.

BY
JOHN JOSEPH GRIFFIN,

SECOND EDITION, REVISED.



LONDON:
PUBLISHED BY JOHN J. GRIFFIN AND SONS,
CHEMICAL AND PHILOSOPHICAL INSTRUMENT MAKERS,
22, GARRICK STREET, COVENT GARDEN, W.C.
1872.

LONDON PRINTED BY WILLIAM CLOWES AND SONS, STAMFORD STREET AND CHARING CROSS.

P R E F A C E.

THE following work contains instructions for ascertaining by chemical experiments the relative proportions of the principal constituents of WINES. The processes described are of easy performance, and such as can, with a little care, be executed by persons not much accustomed to the conduct of chemical experiments. No complicated operations of analysis are recommended; but only such processes of testing as readily yield trustworthy information respecting the chief characteristics of Wines. The work includes an extensive series of original Tables for computing the quantity of ALCOHOL contained in any spirituous liquor, and for explaining the indications of the scales of different European Alcoholometers. Some brief notes are added, on the chemical testing of MUST, and on a few other points in the Manufacture of Wines.

The experimental researches incidental to the production of this work—the trials of instruments and methods of operating, and the systematic testing of nearly fifty wines, as examples—have been conducted by my son, MR. WILLIAM GRIFFIN.

It is hoped that, at a time when a great variety of new wines are daily brought before the public, a work which describes a method of readily ascertaining the approximate composition and character of any wine that may be submitted to trial, will not prove unacceptable.

JOHN J. GRIFFIN.

22, GARRICK STREET, W.C.

London, March 1, 1866.

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LIST OF WINES

THAT HAVE BEEN TESTED CHEMICALLY BY THE PROCESSES
DESCRIBED IN THIS WORK.

1. I ADD to the names of the wines in the following list, a few words descriptive of what I may call their appearance and physical characters. I do this that the reader may know what sort of wines the experiments subsequently described relate to; but I wish it to be understood, that I by no means assume the privilege, or possess the power, to give to the wines in question accurate characters founded upon such qualities as taste, odour, or colour. My knowledge of some of the wines is derived from the examination of only a single bottle, which may, or may not, have been an average sample of its ordinary commercial quality. Such as I found each wine, I describe it. But no judgment formed on the examination of a single bottle of any wine can be applied with safety to the class of wines to which the sample belonged. An experience so limited entitles me to do no more than briefly indicate the prominent points which characterise each wine that was afterwards submitted to the Chemical Tests.

Many samples of these wines were presented to me by Dr. Druitt, author of the popular "Report on Cheap Wines;" several of the Greek wines I received from James L. Denman, Esq.; and the four samples of peculiar dry sherry, Nos. 5, 6, 7, 8 in the list, I owe to the kindness of Dr. Norcott of Southampton. To these gentlemen I beg leave to return my thanks for the assistance thus afforded me.

The other wines named in the list were not selected with any special care. I took such wines as came readiest to hand. The object I had in view was to find in what manner the constituents of *any wine*, good or bad, could be most satisfactorily estimated. A great number of preliminary experiments were made on the very inferior wines marked Nos. 3, 10, 12, 13 in the list. These wines contained abundance of acid, alcohol, sugar, tannin, and colouring matter, and therefore served to test the comparative merits of different methods of analysis which were tried in succession. In consequence of the mixture of methods used in the testing of these four wines, the results are less worthy of attention than those of the testings of the other wines in the list; which

were conducted on the plan described in the following pages, after several other less trustworthy methods had been tried and rejected. It did not appear worth while to test other bottles of these four common wines.

SPANISH AND PORTUGUESE WINES.

1. *Port Wine*, of good quality, ten years in bottle. A fine rich soft wine, with excellent odour.
2. *Port Wine*, said to be genuine as imported; moderately good quality, but quite newly bottled; very sweet; harsher than the foregoing.
3. *Port Wine*, purchased at a public-house in London, probably draught port; colour very dark; taste hot, sweet, heavy, overpowering.
4. *Madeira*, received from an eminent wine-merchant, as quite genuine and recently imported.
- 5, 6, 7, 8. *Sherries*. Characteristic examples of pure and very dry wines. Colour dark yellow-brown. The new-bottled wines, Nos. 6 and 8, were paler in colour than those that had been long in bottle, and they contained a little tannin. The wines Nos. 5 and 7 were free from tannin.
5. *Montilla*, 1854.
6. *Montilla*, 1854, newly bottled.
7. *Oloroso*, 1843.
8. *Oloroso*, 1843, newly bottled.
9. *Sherry*, called Oxford Sherry, pale colour, strong hot taste, valued at 36s. per dozen.
10. *Sherry*, purchased at a public-house in London, dark colour, sweet coarse taste.
11. *Tarragona*, a strong Spanish red wine; colour dark; resembling new port both in appearance and taste.

LONDON GROCERS' WINES. [*Query: Hamburg Wines?*]

12. *Mock Port*, *British Port*, purchased at a grocer's shop at 1s. per bottle. Colour dark, taste burning, disagreeably affecting the throat. Odour and flavour of vinegar and of spices decisive.
13. *Mock Sherry*, *British Sherry*, purchased at a grocer's shop at 1s. per bottle. Colour dark, turbid, very sweet and unpleasantly hot from spices.

GREEK WINES.

14. *Como*. Dark red colour, resembling that of new port; taste strong and sweet, but more acid than port; similar to some kinds of draught port.
15. *Lachryma Christi*. A dark red wine, extremely sweet and high flavoured, like the sweet Tokay wines.

16. *Visanto*. A thick-flowing, orange-coloured wine, extremely sweet and high-flavoured, like No. 15, but a little more acid.
17. *Cyprus*. Colour dark brownish yellow, taste extremely sweet, but accompanied by a strong flavour like that of very dry sherry.
18. *Santorin*. A dry red wine, colour resembling very pale port, taste intermediate between the taste of port and claret, more acid than port.
19. *St. Elie*. A dry white wine; taste slightly acid, like that of Rhine wine, but with a flavour resembling Madeira.
20. *Thera*. A dark sherry colour; full-bodied wine; taste peculiar, somewhat resembling that of Madeira.
21. *Red Keffesia*. A claret-coloured wine; dry, full-bodied, astringent, slightly acid.
22. *White Keffesia*. Colour tawny, resembling raw Sienna; taste like that of Rhine wine. Bottled in March 1864, opened and tested in April 1865.
23. *White Keffesia*. Same as last, and bottled at the same time, but accidentally with a few small flies, which decomposed the wine, and produced an enormous quantity of acid. See a particular account of it in the section on Free Acids, § 133.
24. *Red Mont Hymet*. Light claret colour; taste rather rough and acid, but with a good flavour. I am told that No. 25 more resembles the usual commercial quality.
25. *Red Mont Hymet*. Another sample, less acid than the foregoing.
26. *White Mont Hymet*. A dry wine, slightly acid and with good flavour; an agreeable and cheap dinner wine, 16s. per dozen.

ITALIAN WINES.

27. *White Capri*. Pale cowslip colour; very fragrant, highly flavoured, like sweet Hock.

HUNGARIAN WINES.

28. *St. Georger*. Colour bright yellow; a thick liquid, excessively sweet; one of the Tokay order of wines, but with less flavour than the Greek wines, Nos. 15, 16, 17.
29. *Ofner*. Claret colour; taste between the taste of port and of claret, but rather rough.
30. *Erlaure*. Colour between that of port and claret; taste like that of claret, but less rough.
31. *Szamorodny*. A species of dry Tokay. Colour very pale brown, taste like that of acid Hock, but flat. The sample was, however, said to be spoiled.
32. *Dioszeger Bakator Auslese*. Colour of Hock, taste strong with much fragrance, like the superior kinds of Rhine wine.
33. *White Diusi*. Light yellow colour, taste like that of Rhine wine,

but with more fragrance than the lower kinds of Rhine wine; a strong wine.

AUSTRIAN WINES.

34. *Red Voeslauer*, Schlumberger's. Colour dark claret; taste between that of light port and of claret; odour tolerably powerful, similar to that of port. A pleasant dinner wine.

FRENCH WINES.

35. *Champagne*, Sillery-grand-Mousseux. Good quality; said to be a genuine sample.
36. *Fronsac*. Claret colour; taste between that of port and of claret, but acid. It came to me ticketed, "*Open five months, too strong and sour at starting.*" I had a second bottle, which contained only 4.00 grains of total acidity and .78 grains of volatile acid. This was said to be of the ordinary commercial strength; but it went mouldy in a few days.
37. *Vin Ordinaire (Red)*. A common claret, purchased at a City Restaurant's, as their lowest quality. Acid, but drinkable. Some of its acid appeared from the testing to have been neutralised by alkali.
38. *Paysan's Bordeaux*. A weak claret, but less acid than the preceding, and with a purer taste.
39. *St. Julien*, 1858. A first-rate claret, recommended by Dr. Druitt, by whom I was favoured with a sample. It is described by him as "full-bodied, deep colour, age in bottle, crust, not sour, but decidedly rough."

RHINE WINES.

40. *Gilbey's Castle I. Hock*, at 16s. per dozen, moderately good, not too acid for agreeable drink.
41. *Rudesheimer*. A sample of Rhine wine of first-rate quality, 84s. per dozen.

2. The processes of Chemical Testing performed upon these Wines have had in view the estimation of the quantities of the following constituents of each wine:—

1. The Alcohol.
2. The Free Acid, distinguishing—
 - a. The Volatile Acid.
 - b. The Fixed Acid.
3. The Sugar.
4. The Solid Residue, obtained by evaporating the wine and drying the residue at 230° F.

5. The Ash left when the residue is calcined.
6. The quantity of Potash Hydrate (KHO) equal to the caustic or carbonated alkali found in the ash.
3. The Results of the Testing operations are stated in the two Tables printed on pages 6 to 13.

TABLE I. exhibits the WEIGHT IN ENGLISH GRAINS of the several constituents contained in the *Hundredth part of an Imperial Gallon* of each wine. If the decimal points are supposed to be removed from all the columns of figures, excepting column 3, which shows the specific gravities of the wines, the number of grains then indicated are those which are contained in *One Imperial Gallon* of each wine. The grain weight meant is the imperial grain of 7000 to the avoirdupois pound. In order to fix clearly in the mind the STANDARD MEASURE, to which frequent reference will be made throughout this work, I have given in Fig. 1, page 14, a representation of the *exact size* of a bottle that contains the HUNDREDTH PART OF AN IMPERIAL GALLON, when it is filled up to the mark *α α*, at 62° of Fahrenheit's thermometer.

TABLE II. exhibits the Constituents of the Wines in reference to a different standard of comparison. In Table I., the standard is an *absolute quantity* of wine taken both by measure and by weight; the *measure* being a centigallon, or 100 septems, or the hundredth part of a gallon, and the *weight* being the number of grains specified in column 4 of the Table, with which standard quantity the several constituents of each wine are compared in absolute quantities weighing as many grains as are expressed in the Table. In Table II., the quantity of wine taken as a standard is simply 100 *parts by weight*, and with this standard the several constituents are compared in *per-centages* by weight, with the exception of the quotations in columns 4 and 5.

These two methods of stating the results of our experimental researches are adopted in order that the method to be pursued in this work may be rendered clear. The precise meaning of the headings of the columns of these Tables will be explained in subsequent chapters of this work.

For the sake of those who are accustomed to use the French decimal weights and measures, I have given, at page 6, an easy formula for converting the results which TABLE I. gives as *grains in a gallon* into corresponding results expressed as *grammes in a litre*. This will facilitate the comparison of results to be obtained by methods described in this work with other results obtained by continental chemists, and published in various books and journals. I may add here the converse problem. To convert French statements in decimals, such as *grammes in a litre*, into terms that correspond with those in Tables I. and II., you have only to multiply the *grammes* by 0.7. The product expresses *grains in a centigallon*. Hence, 1 gramme per litre is .7 grain per centigallon, 7 grains per decigallon, or 70 grains per gallon.

TABLE I.

TABLE I.—WEIGHT in GRAINS of the CONSTITUENTS of a
 If the Decimal Points are removed, the
 If the Numbers are divided by .70, the results

1 No.	2 Names of the Wines.	3 Specific Gravity at 60° Fahr.	4 Wine.	5 Absolute, Alcohol.
	<i>Spanish and Portuguese Wines.</i>			
1	Old-bottled Port . . . .	.9989	699.26	141.86
2	Newly-bottled Port	1.0036	702.55	121.56
3	Public-house Port . . . .	.9997	699.80	140.50
4	Madeira	1.0041	702.90	114.20
5	Sherry, Montilla, 1854 . . . .	.9872	691.04	114.88
6	Ditto, newly bottled . . . .	.9865	690.53	121.28
7	Sherry, Oloroso, 1843 . . . .	.9882	691.77	104.36
8	Ditto, newly bottled . . . .	.9880	691.60	111.60
9	Sherry, Oxford . . . . .	.9937	695.59	141.86
10	Public-house Sherry . . . .	.9966	697.60	122.10
11	Tarragona . . . . .	.9960	697.20	107.50
	<i>London Grocers' Wines.</i>			
12	British Port	1.0239	716.75	105.60
13	British Sherry	1.0046	703.20	95.34
	<i>Greek Wines.</i>			
14	Como	1.0162	711.34	89.86
15	Lachryma Christi	1.0794	755.56	73.32
16	Visanto	1.0982	768.74	49.50
17	Cyprus	1.0620	743.40	75.00
18	Santorin . . . . .	.9984	698.90	66.32
19	St. Elie . . . . .	.9957	697.01	74.76
20	Thera . . . . .	.9919	694.34	88.90
21	Red Keffesia . . . . .	.9940	695.83	60.16
22	White Keffesia . . . . .	.9908	693.56	82.58
23	Ditto, with flies in it . . . .	.9932	695.24	74.76
24	Red Mont Hymet . . . . .	.9979	698.52	74.20
25	Ditto . . . . .	.9950	696.50	70.94
26	White Mont Hymet . . . . .	.9918	694.26	68.32
1	2	3	4	5

TABLE I.

CENTIGALLON [= $\frac{1}{100}$ Gallon = 100 Septems] of certain WINES.
 Numbers show Grains in a Gallon.
 show Grammes in a Litre [correct to 1 in 500].

6	7	8	9	10	11	12	13	1
Total Acidity.	Volatile Acids at $\frac{100}{100}$.	Fixed Acids.	Sugar.	Solid Residue at 230° F.	Ash.	Potash KHO.	Neutral Organic Bodies.	No.
2.50	.44	2.06	23.15	40.56	1.79	.35	13.49	1
2.65	.44	2.21	33.33	47.50	2.50	.95	8.79	2
2.50	.54	1.96	35.72	36.00	3.00	.84	?	3
4.00	1.00	3.00	27.03	34.70	3.65	.78	.40	4
3.00	.76	2.24	4.17	17.20	3.20	.29	7.58	5
3.00	.68	2.32	4.55	17.45	3.25	.29	7.40	6
2.80	.48	2.32	4.42	17.40	3.20	.29	7.45	7
2.80	.48	2.32	4.42	17.40	3.20	.29	7.45	8
3.25	.75	2.50	16.67	34.43	3.50	.43	11.52	9
3.60	1.36	2.24	21.00	32.00	..	.18	?	10
3.25	.85	2.40	16.67	31.10	3.20	.76	8.16	11
4.50	1.80	2.70	52.63	56.43	4.71	1.26	?	12
3.00	.55	2.45	34.48	38.25	3.20	.86	?	13
4.00	1.06	2.94	23.81	59.16	3.70	.92	27.88	14
4.30	.80	3.50	142.86	178.56	3.62	.76	28.44	15
4.60	.94	3.66	170.07	183.00	4.10	.85	4.37	16
4.70	.92	3.78	111.11	121.80	3.28	.76	2.87	17
4.45	.40	4.05	2.70	23.08	2.74	.63	13.17	18
4.55	.38	4.17	1.67	16.22	2.08	.62	7.84	19
3.50	.85	2.65	1.25	14.60	1.20	.56	9.10	20
3.70	.80	2.90	0.00	16.60	1.60	.38	12.16	21
3.80	.98	2.82	2.00	15.10	1.29	.50	8.60	22
13.00	6.85	6.15	1.85	14.74	1.26	.45	5.04	23
4.95	1.58	3.37	0.00	23.20	1.80	.65	18.18	24
3.70	1.14	2.56	0.00	18.60	1.80	.32	14.52	25
3.20	.59	2.61	0.00	14.34	1.34	.36	10.41	26
6	7	8	9	10	11	12	13	1

TABLE I.—Weight in Grains of the Constituents

1 No.	2 Names of the Wines.	3 Specific Gravity at 60° Fahr.	4 Wine.	5 Absolute Alcohol.
	<i>Italian Wines.</i>			
27	White Capri . . . . .	.9913	693.90	72.14
	<i>Hungarian Wines.</i>			
28	St. Georger	1.0757	752.98	58.36
29	Ofner . . . . .	.9937	695.60	60.16
30	Erlaure . . . . .	.9933	695.30	61.92
31	Szamorodny . . . . .	.9911	693.74	66.90
32	Dioszegyer Bakator . . . .	.9918	694.28	83.82
33	White Diasi . . . . .	.9908	693.56	104.64
	<i>Austrian Wines.</i>			
34	Red Voelslauer . . . . .	.9924	694.70	71.18
	<i>French Wines.</i>			
35	Champagne	1.0341	723.90	57.54
36	Fronsac . . . . .	.9941	695.87	74.76
37	Vin Ordinaire . . . . .	.9926	694.85	48.56
38	Paysan's Bordeaux . . . .	.9962	697.34	51.04
39	St. Julien, 1858 . . . . .	.9952	696.64	68.56
	<i>Rhine Wines.</i>			
40	Castle I. Hock, 16s. . . . .	.9954	696.78	46.20
41	Rudesheimer, 84s. . . . .	.9930	695.10	92.60
42	Brandy, good . . . . .	.9344	654.10	303.40
43	Brandy, common . . . . .	.9414	659.00	278.67
44	Rum . . . . .	.9414	659.00	272.04
45	Gin . . . . .	.9649	675.42	214.28
46	Juice of over-ripe Grapes . .	1.0660	746.22	..
47	Juice of Red Currants . . .	1.0540	737.80	..
1	2	3	4	5

of a Centigallon of certain Wines—*continued*.

6 Total Acidity.	7 Volatile Acids at $\frac{80}{100}$.	8 Fixed Acids.	9 Sugar.	10 Solid Residue at 230° F.	11 Ash.	12 Potash, KHO.	13 Neutral Organic Bodies.	1 No.
4.50	1.28	3.22	3.33	13.60	2.00	.73	4.34	27
4.60	.57	4.03	133.00	155.00	2.30	.49	15.80	28
3.75	.75	3.00	1.72	23.00	2.00	.67	15.94	29
3.60	.52	3.08	0.00	17.14	1.34	.45	12.55	30
4.30	.60	3.70	2.00	13.40	1.00	.45	6.89	31
4.25	.48	3.77	3.11	13.16	1.26	.46	4.87	32
4.90	1.28	3.62	3.85	20.60	1.76	.25	11.25	33
3.75	.45	3.30	2.00	13.60	2.20	.95	5.78	34
3.75	..	..	76.92	89.80	1.80	.34	8.07	35
5.00	1.90	3.10	2.60	16.40	1.90	.28	8.06	36
5.00	.74	4.26	.78	35.00	3.10	.87	26.69	37
3.40	.40	3.00	.63	14.20	2.00	.62	8.53	38
4.50	.95	3.55	1.72	18.60	2.80	.56	10.73	39
4.40	.40	4.00	0.00	15.40	1.60	.56	10.11	40
4.40	..	..	1.18	12.80	1.20	.50	6.79	41
.03	..	..	1.70	..	..	..	..	42
.20	..	..	.00	..	..	..	..	43
.45	..	..	2.20	..	..	..	..	44
.00	..	..	25.00	..	..	..	..	45
2.10	.00	..	104.17	..	..	..	..	46
21.00	.00	..	39.68	..	..	..	..	47
6	7	8	9	10	11	12	13	1

TABLE II.—PER CENTAGES of the

1 No.	2 Names of the Wines.	3 Absolute Alcohol by Weight.	4 Absolute Alcohol by Volume.	5 Proof Spirit in Degrees of Sikes.
	<i>Spanish and Portuguese Wines.</i>			
1	Old-bottled Port	20.29	25.53	44.74
2	Newly-bottled Port	17.30	21.88	38.34
3	Public-house Port	20.08	25.29	44.32
4	Madeira	16.25	20.55	36.01
5	Sherry, Montilla, 1854 . . .	16.62	20.67	36.22
6	Ditto, newly bottled	17.56	21.83	38.26
7	Sherry, Oloroso, 1843 . . .	15.09	18.78	32.91
8	Ditto, newly bottled	16.14	20.08	35.19
9	Sherry, Oxford	20.39	25.53	44.74
10	Public house Sherry	17.50	21.97	38.50
11	Tarragona	15.42	19.35	33.91
	<i>London Grocers' Wines.</i>			
12	British Port	14.73	19.00	33.30
13	British Sherry	13.56	17.16	30.07
	<i>Greek Wines.</i>			
14	Como	12.63	16.17	28.34
15	Lachryma Christi	9.70	13.20	23.13
16	Visanto	6.44	8.91	15.61
17	Cyprus	10.09	13.50	23.66
18	Santorin	9.49	11.94	20.92
19	St. Elie	10.73	13.45	23.57
20	Thera	12.80	16.00	28.04
21	Red Keffesia	8.65	10.83	18.98
22	White Keffesia	11.91	14.86	26.04
23	Ditto, with flies in it . . .	10.75	13.45	23.57
24	Red Mont Hymet	10.62	13.35	23.40
25	Ditto	10.19	12.77	22.38
26	White Mont Hymet	9.84	12.30	21.56
1	2	3	4	5

CONSTITUENTS of certain WINES.

6	7	8	9	10	11	12	13	1
•Total Acidity.	Volatile Acids at $\frac{50}{100}$.	Fixed Acids.	Sugar.	Solid Residue at 230° F.	Ash.	Potash, KHO.	Neutral Organic Bodies.	No.
.36	.06	.30	3.31	5.80	.26	.05	1.93	1
.38	.06	.32	4.74	6.76	.36	.14	1.23	2
.36	.08	.28	5.10	5.14	.43	.12	?	3
•.57	.14	.43	3.85	4.94	.52	.11	.06	4
.43	.11	.32	.60	2.49	.46	.04	1.10	5
.43	.10	.33	.66	2.53	.47	.04	1.07	6
.40	.07	.33	.64	2.52	.46	.04	1.08	7
.40	.07	.33	.64	2.52	.46	.04	1.08	8
.47	.11	.36	2.40	4.95	.50	.06	1.66	9
.52	.20	.32	3.01	4.59	..	.03	?	10
.47	.12	.35	2.39	4.46	.46	.11	1.17	11
.63	.25	.38	7.34	7.87	.66	.18	?	12
.43	.08	.35	4.90	5.44	.46	.12	?	13
.56	.15	.41	3.35	8.32	.52	.13	3.92	14
.57	.11	.46	18.91	23.63	.48	.10	3.77	15
.60	.12	.48	22.12	23.81	.53	.11	.57	16
.63	.12	.51	14.95	16.38	.44	.10	.39	17
.64	.06	.58	.39	3.30	.39	.09	1.88	18
.65	.05	.60	.24	2.33	.30	.09	1.12	19
.50	.12	.38	.18	2.10	.17	.08	1.31	20
.53	.11	.42	.00	2.39	.23	.05	1.75	21
.55	.14	.41	.29	2.18	.19	.07	1.24	22
1.87	.99	.88	.27	2.12	.18	.06	.72	23
.71	.23	.48	.00	3.32	.26	.09	2.60	24
.53	.16	.37	.00	2.67	.26	.05	2.08	25
.46	.08	.38	.00	2.07	.19	.05	1.50	26
6	7	8	9	10	11	12	13	1

TABLE II.—Per Centages of the Constituents

1 No.	2 Names of the Wines.	3 Absolute Alcohol by Weight.	4 Absolute Alcohol by Volume.	5 Proof Spirit in Degrees of Sikes.
	<i>Italian Wines.</i>			
27	White Capri	10.40	12.98	22.75
	<i>Hungarian Wines.</i>			
28	St. Georger	7.75	10.50	18.40
29	Ofner	8.65	10.83	18.98
30	Erlaure	8.91	11.14	19.52
31	Szamorodny	9.64	12.04	21.10
32	Dioszeger Bakator	12.07	15.08	26.43
33	White Diasi	15.09	18.83	33.00
	<i>Austrian Wines.</i>			
34	Red Voeslauer	10.25	12.81	22.45
	<i>French Wines.</i>			
35	Champagne	7.95	10.36	18.16
36	Fronsac	10.74	13.45	23.57
37	Vin Ordinaire	6.99	8.74	15.32
38	Paysan's Bordeaux	7.32	9.19	16.11
39	St. Julien, 1858	9.84	12.34	21.63
	<i>Rhine Wines.</i>			
40	Castle I. Hock, 16s. dozen .	6.63	8.31	14.56
41	Rudesheimer, 84s. dozen . .	13.32	16.66	29.20
	—			
42	Brandy, good	46.38	54.60	95.69
43	Brandy, common	42.29	50.15	87.89
44	Rum	41.28	48.96	85.80
45	Gin	31.73	38.56	67.50
	—			
46	Juice of over-ripe Grapes . .	..	..	..
47	Juice of Red Currants . . .	..	..	..
1	2	3	4	5

of certain Wines—*continued.*

6 Total Acidity.	7 Volatile Acids at $\frac{80}{100}$.	8 Fixed Acids.	9 Sugar.	10 Solid Residue at 230° F.	11 Ash.	12 Potash, KHO.	13 Neutral Organic Bodies.	1 No.
.65	.19	.46	.48	1.96	.29	.11	.63	27
.61	.08	.53	17.66	20.58	.31	.06	2.10	28
.54	.11	.43	.25	3.31	.29	.10	2.29	29
.52	.08	.44	.00	2.47	.20	.06	1.80	30
.62	.09	.53	.29	1.93	.14	.06	.99	31
.61	.07	.54	.45	1.90	.18	.07	.70	32
.71	.19	.52	.56	2.97	.25	.04	1.62	33
.54	.06	.48	.29	1.96	.32	.14	.83	34
.52	..	..	10.63	12.41	.25	.05	1.11	35
.72	.27	.45	.37	2.36	.27	.04	1.16	36
.72	.11	.61	.11	5.04	.45	.13	3.84	37
.49	.06	.43	.09	2.04	.29	.09	1.22	38
.65	.14	.51	.25	2.67	.40	.08	1.54	39
.63	.06	.57	.00	2.21	.23	.08	1.45	40
.63	..	..	.17	1.84	.17	.07	.98	41
.01	..	..	.26	..	..	..	..	42
.03	..	..	.00	..	..	..	..	43
.07	..	..	.33	..	..	..	..	44
.00	..	..	3.70	..	..	..	..	45
.28	..	..	13.96	..	..	..	..	46
2.85	..	..	5.38	..	..	..	..	47
6	7	8	9	10	11	12	13	1

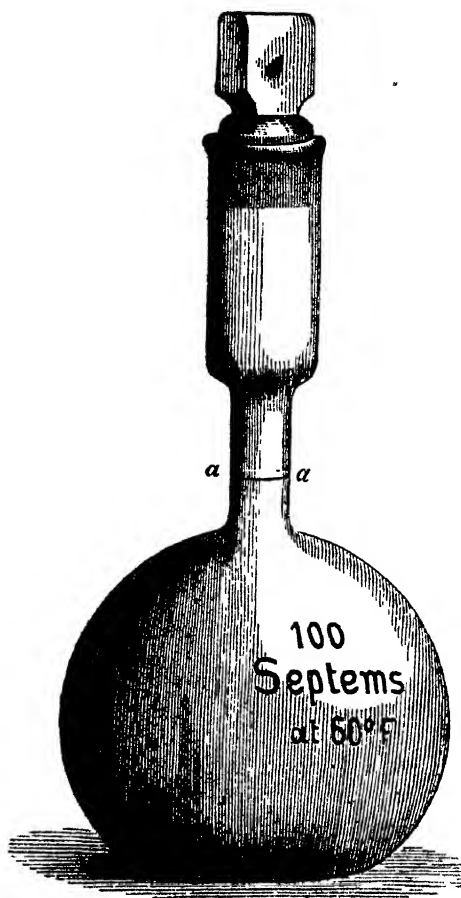
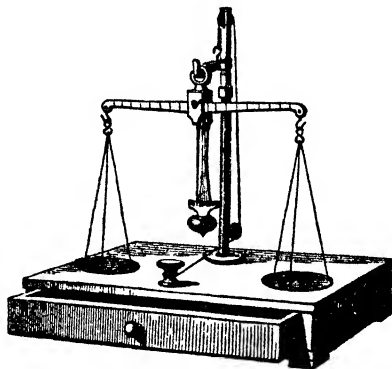


Figure 1.—Standard Centigallon Measure.

DETERMINATION OF THE SPECIFIC GRAVITY OF WINES AND SPIRITS.

4. The specific gravity of a wine or spirit is most accurately determined by weighing a fixed quantity of it. The apparatus required for this experiment is as follows:—1, a balance; 2, a set of grain weights; 3, a specific gravity bottle; 4, a counterpoise for the bottle; 5, a pipette; 6, a narrow glass tube; 7, a thermometer with Fahrenheit's scale.

5. The balance represented by Fig. 2 is sufficient for this purpose. It has a beam of about $10\frac{1}{2}$ inches in length, with brass pans



$2\frac{1}{2}$ inches diameter. It will carry 4 ounces in each pan, and with that weight will turn with $\frac{1}{20}$ th of a grain. When loaded with the specific gravity bottle described below, and with a corresponding counterpoise and weights, it will turn with $\frac{1}{20}$ th of a grain. This is a cheap balance. Those who wish to make extremely accurate researches may provide themselves with a more delicate balance; but the one here described serves for the experiments described in this work.

6. The grain weights must contain the following series:—600, 300, 200, 100; 60, 30, 20, and 10 grains in brass; and 6, 3, 2, 1; .6, .3, .2, .1; .06, .03, .02, .01 grain in platinum, accompanied by

riders for moving on the graduated beam of the balance. The rider has the form of Fig. 3. When put in the pan of the balance, it weighs .1 grain, but when put on the beam, it weighs .01 to .09 grain, according to the notch on the beam where it is made to rest.



3.

7. The specific gravity bottle should have the *form and size* represented by Fig. 1, page 14. When this bottle is filled with pure distilled water, at the temperature of 62° Fahr., it contains 700 imperial grains of water, which is the *tenth* part of a pound of water and the *hundredth* part of an imperial gallon. The exact measure is indicated by the line *a a*, cut on the neck of the bottle. The quantity of water should be so adjusted in the bottle, that the lowest part of the curved surface of the water, when seen by looking across the neck of the bottle, touches the line *a a*.

8. The contents of this bottle is said to be the *hundredth part* of a gallon. I have therefore in some places called this measure a *centigallon*. In others, I have called it 100 *septems*; for I divide the centigallon into 100 parts, to each of which I give the name of *septem*, because its capacity is equal to that of *seven* grains of water.

Hence, 100 Septems make a Centigallon.

1000 Septems make a Decigallon.

10000 Septems make a Gallon.

These divisions being strictly decimal, all calculations made by them are extremely convenient, as will be seen in several of the testing processes.

9. The temperature of the water or other liquid to be weighed should be determined by the thermometer for each experiment. All English measures and weights are adjusted at 62° Fahr., according to Act of Parliament. But alcohol and all its dilutions are weighed at 60°. This difference rendering the weights and measures slightly inaccurate. But it is advisable, in all processes with wines and spirits, to operate at 60°, and in all the experiments that are recorded or recommended in this work, it is assumed that 60° Fahr. is the temperature at which the operations are performed.

10. A pipette, see Fig. 12, page 53, is used to fill the specific gravity bottle with water or wine, without wetting the outside of the bottle, and a narrow glass tube or pipette serves to adjust the quantity accurately to the mark on the neck of the bottle.

11. The counterpoise for the specific gravity bottle consists of a brass box, with a moveable stopper or a moveable cover. The weight of it is changeable by putting more or less lead shot into it. When the bottle is to be used for weighing wines, but not for weighing strong solutions of alcohol, the weight of the counterpoise may be made equal to the weight of the bottle *plus* 680 grains; that is to say, the bottle

with 680 grains being put into one of the balance pans, the counterpoise box is to be put into the other pan, and lead shot are to be added till a counterpoise is effected, the final adjustment being made with bits of tinfoil. All the lead shot and bits of tinfoil required for this purpose are to be put into the counterpoise box, which is then ready for use until any accident occurs which changes the weight either of the bottle or the counterpoise, and renders readjustment necessary.

12. It will be seen on reference to Table I., column 4, that the highest weight of 100 septems of any one of the wines recorded in the Table is 768.74 grains, and the lowest weight, 690.53 grains. The difference between these numbers and 680 grains is the number of grains that must be added in weights to the counterpoise in weighing the specific gravity bottle when full of the respective wines.

From	768.74	From	690.53
• Deduct	680.	Deduct	680.

- Difference 88.74 grains. Difference 10.53 grains.

Thus, in one case 88.74 grains in weights serves to weigh 768.74 grains of wine, and in the other case, 10.53 grains in weights serves to weigh 690.53 grains of wine; so that this construction of the counterpoise saves much time in weighing, and much wear and tear of delicate weights. In calculating the weight of each sample so tried, the weights actually used in weighing are to be added to the constant quantity 680 grains.

13. When it is necessary to express the specific gravity of water, wine, or spirit, in figures that refer to water as unity, it is advisable to fix water at 1.0000 at 60° Fahr., and to denote the other liquor by corresponding numbers. Examples of this mode of expression are given in column 3 of Table I. After determining the weight of 100 septems, or a centigallon of liquor, and writing it down in five figures, as shown in column 4, the only other calculation required is that of dividing this number by 7, which gives the specific gravity as expressed in column 3, after changing the position of the decimal point, so as in all cases to leave four figures after the point.

14. When the specific gravity bottle and counterpoise are to be used for weighing strong solutions of alcohol, the counterpoise must not be so heavily weighted. On referring to the last entry in Table IV., it will be seen that the weight of a centigallon of absolute alcohol is only 555.66 grains; while at the line 49.24° it is shown that the bottle full of proof-spirit weighs 643.89 grains. Hence, for weighing all spirits weaker than proof, the counterpoise may be conveniently weighted with 640 grains, while for weighing very strong spirits its load should be reduced to 550. In short, this correction of the counterpoise can be made to suit any projected course of experiments.

15. The thermometer used for ascertaining the temperature of the liquor to be weighed should have the form of Fig. 4, be entirely enclosed in glass, and be narrow enough to go into the neck of the specific gravity bottle, Fig. 1. It must have Fahrenheit's scale, and it would suffice for this particular purpose if the scale did not exceed 70° . But the thermometer that is to be used with the apparatus for drying the solid residue of wines must go up beyond 230° Fahr. When economy is not an object to be striven for, it is advisable to have a small thermometer, with a low scale, for the specific gravity bottle, besides the one intended for other purposes, with a scale going up to about 300° Fahr.



16. The specific gravity bottle and its counterpoise should be kept particularly clean. Each should have a case to preserve it from dirt or injury. When required for use, the bottle should be not only clean but dry; for if any liquor is contained in it, it will mix with the liquor to be examined, and will vitiate the experiment. When the bottle is newly washed, and is not perfectly dry, it should be rinsed out two or three times with small quantities of the liquor that is to be weighed. When filled with this liquor for weighing, the bottle must not be heedlessly handled with warm hands, nor be placed near the face, nor put in any situation where it can be needlessly warmed. Neither should the counterpoise or weights be carelessly handled with warm fingers. In all matters relating to weighing, it should be borne in mind that everything concerned in the operation should, as far as possible, be made to have the temperature of 60° Fahr. It is very desirable that the room in which the experiments are to be made, and in which the apparatus, test liquors, wines to be tested, &c., are placed, should be heated to that temperature.

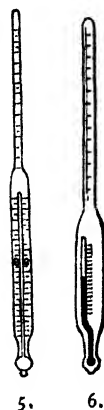
HYDROMETERS.

17. The testing operations described in this work are all to be performed on small quantities of liquors, and I recommend the weights and densities to be ascertained by weighing in a bottle, and not by using hydrometer spindles, which cannot give results to be at all compared for accuracy with those procured by weighing.

But, for commercial purposes, and when plenty of liquor for trial is at command, the hydrometer has the three great advantages of *handiness*, *cheapness*, and *rapidity of operation*. For those reasons, different varieties of it are much in use, and I shall therefore explain, at considerable length, the relations of their indications as compared with those afforded by weighing the liquids in a bottle.

The principal hydrometers employed by persons connected in any

way with wine or spirit testing are those of SIKES, TRALLS, and GAY-LUSSAC, for spirits, and a saccharometer for estimating the per-centage of solutions of sugar, or the relations of solutions of sugar to the composition of grape juice. In the next section, under the head of "Alcohol Tables," I shall give a detailed account of the relations which the different alcoholometers bear to one another. The description of the saccharometer will be more properly placed in the account that is to be given of the composition of Must. Figs. 5 and 6 exhibit two forms of hydrometers, both containing thermometers; but the thermometer is not necessarily connected with the hydrometer. Sikes's alcoholometer can be procured, like these, of glass, but the Excise instrument is of brass, and consists of a spindle and a series of weights.



ALCOHOL TABLES.

18. The whole of the Tables in this section are calculated for the temperature of 60° Fahrenheit, at which temperature a centigallon (= 100 septems) of water is assumed to weigh 700 grains, and the imperial gallon 100 times that quantity.

19. Throughout the Tables, the numbers that express Grains in a Centigallon, if divided by $\cdot 70$, express Grammes in a Litre. And conversely, numbers that express Grammes in a Litre, if multiplied by $\cdot 70$, express Grains in a Centigallon.

TABLE III.—DILUTED ALCOHOL, CONTAINING FROM 0 to 12 PER CENT. BY WEIGHT OF ABSOLUTE ALCOHOL. See pages 21 to 26.

20. The fundamental numbers in this Table are those contained in columns 1 and 2, which are taken from a Memoir "*On the Preparations of absolute Alcohol, and the Composition of Proof Spirit*," by Mr. JOSEPH DRINKWATER, an officer of the Inland Revenue Service, which Memoir was presented to the Chemical Society in the year 1848 by Mr. Graham, Master of the Mint. See *Memoirs of the Chemical Society*, 1848, page 447.

Besides giving the numbers that appear in columns 1 and 2 of this Table, Mr. Drinkwater determined the specific gravity of absolute alcohol at 60° F. to be $0\cdot 79381$, and the composition of proof-spirit to be—

Alcohol by weight	49 \cdot 24
Water by weight	50 \cdot 76
<hr/>	
Together	= 100 \cdot 00

And its specific gravity at 60° F. to be $\cdot 91984$.

This was the first accurate demonstration of the composition of proof-spirit, and it seems to me to be so important, that I have used it in determining many of the numbers that are contained in the present series of Alcohol Tables; and, in order that the reader may be able to appreciate the degree of trustworthiness of the numbers contained in the various columns of these Tables, I shall describe the calculations by which they have been obtained, and by which, where needful, they may be corrected.

21. *Column 3.*—The numbers contained in column 3 of Table III. are obtained by multiplying the numbers of column 2 by 7, and then setting off two decimal figures instead of four. The product then expresses the weight in grains of 100 septems of the liquid; and, if the decimal point is supposed to be taken away, the numbers will represent the weight in grains of a gallon of the liquid.

[Continued at page 26.]

TABLE III.—DILUTED ALCOHOL, containing from 0 to 12 Per Cent. by Weight of ABSOLUTE ALCOHOL.

1 Absolute Alcohol per Cent. by Weight.	2 Specific Gravity of the Diluted Alcohol at 60° F.	3 Weight in Grains of 100 Septems of the Diluted Alcohol.	4 Weight in Grains of the Absolute Alcohol in 100 Septems.	5 Weight in Grains of the Proof Spirit in 100 Septems.	6 Per Centage of Proof Spirit at 60° F., after Sikes.
0.00	1.0000	700.00	.00	.00	.00
0.05	.9999	699.93	.35	.71	.11
0.11	.9998	699.86	.77	1.56	.24
0.16	.9997	699.79	1.12	2.27	.35
0.21	.9996	699.72	1.47	2.98	.46
0.26	.9995	699.65	1.82	3.69	.57
0.32	.9994	699.58	2.24	4.55	.71
0.37	.9993	699.51	2.59	5.26	.82
0.42	.9992	699.44	2.94	5.97	.93
0.47	.9991	699.37	3.29	6.68	1.04
0.53	.9990	699.30	3.71	7.53	1.17
0.58	.9989	699.23	4.06	8.24	1.28
0.64	.9988	699.16	4.47	9.09	1.41
0.69	.9987	699.09	4.82	9.80	1.52
0.74	.9986	699.02	5.17	10.51	1.63
0.80	.9985	698.95	5.59	11.36	1.76
0.85	.9984	698.88	5.94	12.06	1.87
0.91	.9983	698.81	6.36	12.91	2.01
0.96	.9982	698.74	6.71	13.62	2.12
1.02	.9981	698.67	7.13	14.47	2.25
1.07	.9980	698.60	7.48	15.18	2.36
1.12	.9979	698.53	7.82	15.89	2.47
1.18	.9978	698.46	8.24	16.74	2.60
1.23	.9977	698.39	8.59	17.45	2.71
1.29	.9976	698.32	9.01	18.29	2.84
1.34	.9975	698.25	9.36	19.00	2.95
1.40	.9974	698.18	9.77	19.85	3.08
1.45	.9973	698.11	10.12	20.56	3.19
1.51	.9972	698.04	10.54	21.41	3.32
1.56	.9971	697.97	10.89	22.11	3.43
1.61	.9970	697.90	11.24	22.82	3.54
1.67	.9969	697.83	11.65	23.67	3.68
1	2	3	4	5	6

TABLE III.—Diluted Alcohol from 0 to 12 per Cent.—*continued*.

1	2	3	4	5	6
Absolute Alcohol per Cent. by Weight.	Specific Gravity of the Diluted Alcohol at 60° F.	Weight in Grains of 100 Septems of the Diluted Alcohol.	Weight in Grains of the Absolute Alcohol in 100 Septems.	Weight in Grains of the Proof Spirit in 100 Septems.	Per Centage of Proof Spirit at 60° F., after Sikes.
1.73	.9968	697.76	12.07	24.51	3.81
1.78	.9967	697.69	12.42	25.22	3.92
1.83	.9966	697.62	12.77	25.93	4.03
1.89	.9965	697.55	13.18	26.78	4.16
1.94	.9964	697.48	13.53	27.48	4.27 _r
1.99	.9963	697.41	13.88	28.18	4.38
2.05	.9962	697.34	14.30	29.03	4.51
2.11	.9961	697.27	14.71	29.88	4.64
2.17	.9960	697.20	15.13	30.73	4.77
2.22	.9959	697.13	15.48	31.43	4.88
2.28	.9958	697.06	15.89	32.28	5.01
2.34	.9957	696.99	16.31	33.12	5.14
2.39	.9956	696.92	16.66	33.83	5.25
2.45	.9955	696.85	17.07	34.67	5.39
2.51	.9954	696.78	17.49	35.52	5.52
2.57	.9953	696.71	17.91	36.36	5.65
2.62	.9952	696.64	18.25	37.07	5.76
2.68	.9951	696.57	18.67	37.91	5.89
2.74	.9950	696.50	19.08	38.76	6.02
2.79	.9949	696.43	19.43	39.46	6.13
2.85	.9948	696.36	19.85	40.31	6.26
2.91	.9947	696.29	20.26	41.15	6.39
2.97	.9946	696.22	20.68	41.99	6.52
3.02	.9945	696.15	21.02	42.70	6.63
3.08	.9944	696.08	21.44	43.54	6.76
3.14	.9943	696.01	21.85	44.39	6.89
3.20	.9942	695.94	22.27	45.23	7.02
3.26	.9941	695.87	22.69	46.07	7.16
3.32	.9940	695.80	23.10	46.92	7.29
3.37	.9939	695.73	23.45	47.62	7.40
3.43	.9938	695.66	23.86	48.46	7.53
3.49	.9937	695.59	24.28	49.30	7.66
3.55	.9936	695.52	24.69	50.14	7.79
1	2	3	4	5	6

TABLE III.—Diluted Alcohol from 0 to 12 per Cent.—*continued*.

1	2	3	4	5	6
Absolute Alcohol per Cent. by Weight.	Specific Gravity of the Diluted Alcohol at 60° F.	Weight in Grains of 100 Septems of the Diluted Alcohol.	Weight in Grains of the Absolute Alcohol in 100 Septems.	Weight in Grains of the Proof Spirit in 100 Septems.	Per Centage of Proof Spirit at 60° F., after Sikes.
3.61	.9935	695.45	25.11	50.99	7.92
3.67	.9934	695.38	25.52	51.83	8.05
3.73	.9933	695.31	25.94	52.67	8.18
3.78	.9932	695.24	26.28	53.37	8.29
3.84	.9931	695.17	26.69	54.21	8.42
3.90	.9930	695.10	27.11	55.06	8.55
3.96	.9929	695.03	27.52	55.90	8.68
4.02	.9928	694.96	27.94	56.74	8.81
4.08	.9927	694.89	28.35	57.58	8.94
4.14	.9926	694.82	28.77	58.42	9.07
4.20	.9925	694.75	29.18	59.26	9.20
4.27	.9924	694.68	29.66	60.24	9.36
4.33	.9923	694.61	30.08	61.08	9.49
4.39	.9922	694.54	30.49	61.92	9.62
4.45	.9921	694.47	30.90	62.76	9.75
4.51	.9920	694.40	31.32	63.60	9.88
4.57	.9919	694.33	31.73	64.44	10.01
4.64	.9918	694.26	32.21	65.42	10.16
4.70	.9917	694.19	32.63	66.26	10.29
4.76	.9916	694.12	33.04	67.10	10.42
4.82	.9915	694.05	33.45	67.94	10.55
4.88	.9914	693.98	33.87	68.78	10.68
4.94	.9913	693.91	34.28	69.62	10.81
5.01	.9912	693.84	34.76	70.60	10.96
5.07	.9911	693.77	35.17	71.43	11.09
5.13	.9910	693.70	35.59	72.27	11.22
5.20	.9909	693.63	36.07	73.25	11.38
5.26	.9908	693.56	36.48	74.09	11.51
5.32	.9907	693.49	36.89	74.93	11.64
5.39	.9906	693.42	37.38	75.90	11.79
5.45	.9905	693.35	37.79	76.74	11.92
5.51	.9904	693.28	38.20	77.58	12.05
5.58	.9903	693.21	38.68	78.56	12.20
1	2	3	4	5	6

TABLE III.—Diluted Alcohol from 0 to 12 per Cent.—*continued*.

1	2	3	4	5	6
Absolute Alcohol per Cent. by Weight.	Specific Gravity of the Diluted Alcohol at 60° F.	Weight in Grains of 100 Septems of the Diluted Alcohol.	Weight in Grains of the Absolute Alcohol in 100 Septems.	Weight in Grains of the Proof Spirit in 100 Septems.	Per Centage of Proof Spirit at 60° F., after Sikes.
5.64	.9902	693.14	39.09	79.39	12.33
5.70	.9901	693.07	39.50	80.23	12.46
5.77	.9900	693.00	39.99	81.21	12.61
5.83	.9899	692.93	40.40	82.04	12.74
5.89	.9898	692.86	40.81	82.88	12.87
5.96	.9897	692.79	41.29	83.86	13.02
6.02	.9896	692.72	41.70	84.69	13.15
6.09	.9895	692.65	42.18	85.67	13.30
6.15	.9894	692.58	42.59	86.50	13.43
6.22	.9893	692.51	43.07	87.48	13.59
6.29	.9892	692.44	43.55	88.45	13.74
6.35	.9891	692.37	43.97	89.29	13.87
6.42	.9890	692.30	44.45	90.27	14.02
6.49	.9889	692.23	44.93	91.24	14.17
6.55	.9888	692.16	45.34	92.07	14.30
6.62	.9887	692.09	45.82	93.05	14.45
6.69	.9886	692.02	46.30	94.02	14.60
6.75	.9885	691.95	46.71	94.86	14.73
6.82	.9884	691.88	47.19	95.83	14.88
6.89	.9883	691.81	47.67	96.80	15.03
6.95	.9882	691.74	48.08	97.64	15.16
7.02	.9881	691.67	48.56	98.61	15.31
7.09	.9880	691.60	49.03	99.58	15.47
7.16	.9879	691.53	49.51	100.56	15.62
7.23	.9878	691.46	49.99	101.53	15.77
7.30	.9877	691.39	50.47	102.50	15.92
7.37	.9876	691.32	50.95	103.47	16.07
7.43	.9875	691.25	51.36	104.31	16.20
7.50	.9874	611.18	51.84	105.28	16.35
7.57	.9873	691.11	52.32	106.25	16.50
7.64	.9872	691.04	52.80	107.22	16.65
7.71	.9871	690.97	53.27	108.19	16.80
7.78	.9870	690.90	53.75	109.16	16.95
1	2	3	4	5	6

TABLE III.—Diluted Alcohol from 0 to 12 per Cent.—*continued*.

1	2	3	4	5	6
Absolute Alcohol per Cent. by Weight.	Specific Gravity of the Diluted Alcohol at 60° F.	Weight in Grains of 100 Septems of the Diluted Alcohol.	Weight in Grains of the Absolute Alcohol in 100 Septems.	Weight in Grains of the Proof Spirit in 100 Septems.	Per Centage of Proof Spirit at 60° F., after Sikes.
7.85	.9869	690.83	54.23	110.14	17.10
7.92	.9868	690.76	54.71	111.11	17.26
7.99	.9867	690.69	55.19	112.08	17.41
8.06	.9866	690.62	55.66	113.05	17.56
8.13	.9865	690.55	56.14	114.02	17.71
8.20	.9864	690.48	56.62	114.99	17.86
8.27	.9863	690.41	57.10	115.96	18.01
8.34	.9862	690.34	57.57	116.93	18.16
8.41	.9861	690.27	58.05	117.90	18.31
8.48	.9860	690.20	58.53	118.87	18.46
8.55	.9859	690.13	59.01	119.84	18.61
8.62	.9858	690.06	59.48	120.80	18.76
8.70	.9857	689.99	60.03	121.91	18.93
8.77	.9856	689.92	60.51	122.88	19.08
8.84	.9855	689.85	60.98	123.85	19.23
8.91	.9854	689.78	61.46	124.82	19.38
8.98	.9853	689.71	61.94	125.79	19.54
9.05	.9852	689.64	62.41	126.75	19.69
9.12	.9851	689.57	62.89	127.72	19.84
9.20	.9850	689.50	63.43	128.83	20.01
9.27	.9849	689.43	63.91	129.79	20.16
9.34	.9848	689.36	64.39	130.76	20.31
9.41	.9847	689.29	64.86	131.73	20.46
9.49	.9846	689.22	65.41	132.84	20.63
9.56	.9845	689.15	65.88	133.80	20.78
9.63	.9844	689.08	66.36	134.77	20.93
9.70	.9843	689.01	66.83	135.73	21.08
9.78	.9842	688.94	67.38	136.84	21.25
9.85	.9841	688.87	67.85	137.80	21.40
9.92	.9840	688.80	68.33	138.77	21.55
9.99	.9839	688.73	68.80	139.73	21.70
10.07	.9838	688.66	69.35	140.84	21.87
1	2	3	4	5	6

TABLE III.—Diluted Alcohol from 0 to 12 per Cent.—*continued*.

ADDITIONS TO TABLE III.

1	2	3	4	5	6
Absolute Alcohol per Cent. by Weight.	Specific Gravity of the Diluted Alcohol at 60° F.	Weight in Grains of 100 Septems of the Diluted Alcohol.	Weight in Grains of the Absolute Alcohol in 100 Septems.	Weight in Grains of the Proof Spirit in 100 Septems.	Per Centage of Proof Spirit at 60° F., after Sikes.
10.	.9841	688.87	68.89	139.90	21.73
10.05	.9840	688.82	69.23	140.59	21.83
10.1	.9840	688.78	69.57	141.28	21.94
10.15	.9839	688.73	69.91	141.97	22.05
10.2	.9838	688.69	70.25	142.66	22.16
10.25	.9838	688.64	70.59	143.35	22.26
10.3	.9837	688.60	70.93	144.04	22.37
10.35	.9836	688.55	71.26	144.73	22.48
10.4	.9836	688.51	71.61	145.42	22.59
10.45	.9835	688.46	71.94	146.11	22.69
10.5	.9835	688.42	72.28	146.80	22.80
10.55	.9834	688.37	72.62	147.49	22.91
10.6	.9833	688.32	72.96	148.18	23.01
10.7	.9832	688.23	73.64	149.56	23.23
10.8	.9831	688.14	74.32	150.93	23.44
10.9	.9829	688.05	75.00	152.31	23.66
11.	.9828	687.96	75.68	153.69	23.87
11.1	.9828	687.87	76.35	155.07	24.08
11.2	.9825	687.78	77.03	156.44	24.30
11.3	.9824	687.69	77.71	157.82	24.51
11.4	.9823	687.60	78.39	159.19	24.72
11.5	.9822	687.51	79.06	160.57	24.94
11.6	.9820	687.41	79.74	161.94	25.15
11.7	.9819	687.32	80.42	163.32	25.36
11.8	.9818	687.23	81.09	164.69	25.58
11.9	.9816	687.14	81.77	166.07	25.79
12.	.9815	687.05	82.45	167.44	26.00
1	2	3	4	5	6

22. Mr. Drinkwater's series of numbers diminishes by 1 in the fourth place of decimals; namely, it proceeds from 1'0000 to '9999, 9998, '9997, &c. These intervals are equal to the weight of seven

grains of water in a gallon, or to one septem by measure in ten thousand. This will be considered by most practical men to be sufficiently close reckoning; yet, if desired, intermediate terms can be readily calculated by the following process.

23. *Interpolation.*—Suppose your weighing of 100 septems of dilute alcohol gives the number 699·90, and you want to find the per-centage of alcohol. The number 699·90 is not to be found in the Table. But it falls between the two numbers 699·93 and 699·86, both of which occur in the Table, and one of which indicates ·05 per cent., and the other ·11 per cent. of alcohol; the difference between the two terms being ·06 per cent., which corresponds to the difference between 699·93 and 699·86.

From 699·93 deduct 699·86, the difference is ·07.

From 699·93 deduct 699·90, the difference is ·03.

Then take the proportion—

$$\begin{aligned} 7 : 6 &= 3 : x. \\ : x &= 2\cdot57. \end{aligned}$$

* This 2·57 is to be added to the per-centage ascribed in the Table to the weight 699·93, thus—

$$\cdot05 + \cdot0257 = \cdot0757.$$

This last number is the per-centage of alcohol corresponding to 699·90, the ascertained weight of 100 septems of spirit. This method of interpolating desired numbers can be applied to any of the alcohol Tables, and its use is very frequently necessary.

24. *Column 4.*—The numbers contained in column 4 of Table III., and which represent the weight in grains of absolute alcohol contained in 100 septems of each mixture, are found by multiplying the numbers in column 3 by the numbers in column 1, and dividing the product by 100.

25. *Column 5.*—To find the weight in grains of proof spirit contained in 100 septems of each mixture, as shown in column 5 of Table III., multiply the number of grains of absolute alcohol contained in 100 septems, which number is given in column 4, by 2·0309: the product, after setting off six decimal figures, is the number contained in column 5. The multiplier 2·0309 is derived thus:—According to Drinkwater, 100 parts of proof-spirit contain 49·24 parts of absolute alcohol, and thence we find that 1 of alcohol is equal to 2·0309 of proof-spirit:—For,

$$49\cdot24 : 100\cdot00 = 1 : 2\cdot0309.$$

26. *Column 6.*—To find the *per-centage* of proof-spirit according to Sikes's scale, as exhibited in column 6 of Table III., multiply the number that expresses the grains of proof-spirit in the centigallon, as printed in column 5 of the Table, by 100, and divide the product by 643·89: the result is the per-centage of proof-spirit. The divisor 643·89 is the weight of 100 septems of proof-spirit, derived from

Drinkwater's specific gravity of $\cdot 91984$; since $\cdot 91984 \times 700 = 643\cdot 888$.

27. The lines that show the composition of mixtures, containing from 10 to 12 per cent. of alcohol, and which are specified on page 26 as "ADDITIONS TO TABLE III.," are not given on the authority of Drinkwater, whose Table finished at the line 10 \cdot 07 per cent. The data for these Additions are taken from Table IV., based on Fownes's experiments.

It will be seen that the specific gravities and per-centages of the mixtures, as given by Drinkwater and Fownes respectively, in the few cases where they nearly meet, do not precisely agree; yet the differences are less than those that are found in the Tables furnished by any other two chemists on this subject, and for practical purposes the differences are such as may be safely disregarded.

TABLE IV.—DILUTED ALCOHOL, CONTAINING FROM 0 TO 100 PER CENT. BY WEIGHT OF ABSOLUTE ALCOHOL. See pages 29 to 32.

28. The numbers contained in columns 1 and 2 of Table IV. are taken from a Table published by the late Mr. FOWNES in the *Philosophical Transactions of the Royal Society* for 1847. The three lines that express the per-centages of 19 \cdot 57, 49 \cdot 24, and 89 \cdot 154 have been interpolated.

29. The numbers presented in columns 3, 4, 5, and 6 of this Table have been calculated in the manner described in reference to the numbers presented in the same columns of Table III. But since the series of solutions described in Table IV. proceeds to the two extremes of absolute alcohol on the one hand and absolute water on the other, it presents one or two points of interest that require notice.

30. DRINKWATER, as already stated, found the specific gravity of proof-spirit to be $\cdot 91984$, and its per-centage of absolute alcohol by weight to be 49 \cdot 24. These particulars I have put into Fownes's Table, and the line which records them forms the turning point upon which depends the relations of Sikes's scale to the numbers that represent the specific gravity of mixtures, and the corresponding weight of absolute alcohol.

31. The PROOF-SPIRIT of 49 \cdot 24 per cent. of absolute alcohol, and specific gravity $\cdot 91984$, being marked 100, all mixtures with a smaller proportion of absolute alcohol are said to be UNDER PROOF, and the amount of the under proof is the difference between 100 \cdot 00 and the number expressed in column 6 of Table IV.

32. On the other hand, all mixtures that contain a larger proportion of absolute alcohol than 49 \cdot 24 per cent. are said to be OVER PROOF, and the amount of the over proof is equal to the numbers expressed in column 6, after deducting 100 \cdot 00. Thus, absolute alcohol, or spirits that contain 100 per cent. of absolute alcohol, the last line in the Table, is marked in column 6 as 175 \cdot 25, which signifies that absolute alcohol is 75 $\frac{1}{4}$ per cent. OVER PROOF.

[Continued at page 32.]

TABLE IV.—DILUTED ALCOHOL, containing from 0 to 100 Per Cent by Weight of ABSOLUTE ALCOHOL.

1	2	3	4	5	6
Absolute Alcohol per Cent. by Weight.	Specific Gravity of the Diluted Alcohol at 60° F.	Weight in Grains of 100 Septems of the Diluted Alcohol.	Weight in Grains of the Absolute Alcohol in 100 Septems.	Equivalent of Proof Spirit in Grains.	Per Centage of Proof Spirit at 60° F. after Sikes.
0.	1.0000	700.00	0.00	0.00	0.00
0.5	.9991	699.37	3.50	7.10	1.10
1.	.9981	698.67	6.99	14.19	2.20
2.	.9965	697.55	13.95	28.33	4.40
3.	.9947	696.29	20.98	42.61	6.52
4.	.9930	695.10	27.80	56.47	8.77
5.	.9914	693.98	34.70	70.47	10.94
6.	.9898	692.86	41.57	84.43	13.11
7.	.9884	691.88	48.43	98.36	15.28
8.	.9869	690.83	55.27	112.24	17.43
9.	.9855	689.85	62.09	126.09	19.58
10.	.9841	688.87	68.89	139.90	21.73
11.	.9828	687.96	75.68	153.69	23.87
12.	.9815	687.05	82.45	167.44	26.00
13.	.9802	686.14	89.20	181.15	28.13
14.	.9789	685.23	95.93	194.83	30.26
15.	.9778	684.46	102.67	208.51	32.38
16.	.9766	683.62	109.38	222.14	34.50
17.	.9753	682.71	116.06	235.71	36.61
18.	.9741	681.87	122.74	249.27	38.71
19.	.9728	680.96	129.38	262.76	40.81
19.57	.9721	680.48	133.16	270.43	42.00
20.	.9716	680.12	136.02	276.24	42.90
21.	.9704	679.28	142.65	289.71	44.99
22.	.9691	678.37	149.24	303.09	47.07
23.	.9678	677.46	155.82	316.45	49.15
24.	.9665	676.55	162.37	329.76	51.21
25.	.9652	675.64	168.91	343.04	53.28
26.	.9638	674.66	175.41	356.24	55.33
27.	.9623	673.61	181.87	369.36	57.36
28.	.9609	672.63	188.34	382.50	59.40
29.	.9593	671.51	194.74	395.50	61.42
1	2	3	4	5	6

TABLE IV.—Diluted Alcohol from 0 to 100 per Cent.—*continued.*

1	2	3	4	5	6
Absolute Alcohol per Cent. by Weight.	Specific Gravity of the Diluted Alcohol at 60° F.	Weight in Grains of 100 Septems of the Diluted Alcohol.	Weight in Grains of the Absolute Alcohol in 100 Septems.	Equivalent of Proof Spirit in Grains.	Per Centage of Proof Spirit at 60° F. after Sikes.
30.	.9578	670.46	201.14	408.50	63.44
31.	.9560	669.20	207.45	421.31	65.43
32.	.9544	668.08	213.79	434.19	67.43
33.	.9528	666.96	220.10	447.00	69.42
34.	.9511	665.77	226.36	459.71	71.40
35.	.9490	664.30	232.51	472.20	73.34
36.	.9470	662.90	238.64	484.65	75.27
37.	.9452	661.64	244.81	497.18	77.22
38.	.9434	660.38	250.94	509.63	79.15
39.	.9416	659.12	257.06	522.06	81.08
40.	.9396	657.72	263.09	534.31	82.98
41.	.9376	656.32	269.09	546.49	84.87
42.	.9356	654.92	275.07	558.64	86.76
43.	.9335	653.45	280.98	570.64	88.62
44.	.9314	651.98	286.87	582.60	90.48
45.	.9292	650.44	292.70	594.44	92.32
46.	.9270	648.90	298.49	606.20	94.15
47.	.9249	647.43	304.29	617.98	95.98
48.	.9228	645.96	310.06	629.70	97.80
49.	.9206	644.42	315.77	641.30	99.60
—	—	—	—	—	—
49.24	.91984	643.89	317.05	643.89	100.00
—	—	—	—	—	—
50.	.9184	642.88	321.44	652.81	101.39
51.	.9160	641.20	327.01	664.12	103.14
52.	.9135	639.45	332.51	675.29	104.88
53.	.9113	637.91	338.09	686.63	106.64
54.	.9090	636.30	343.60	697.82	108.38
55.	.9069	634.83	349.16	709.11	110.14
56.	.9047	633.29	354.64	720.24	111.86
57.	.9025	631.75	360.10	731.33	113.58
58.	.9001	630.07	365.44	742.17	115.26
59.	.8979	628.53	370.83	753.12	116.96
1	2	3	4	5	6

TABLE IV.—Diluted Alcohol from 0 to 100 per Cent.—*continued*.

1	2	3	4	5	6
Absolute Alcohol per Cent. by Weight.	Specific Gravity of the Diluted Alcohol at 60° F.	Weight in Grains of 100 Septems of the Diluted Alcohol.	Weight in Grains of the Absolute Alcohol in 100 Septems.	Equivalent of Proof Spirit in Grains.	Per Centage of Proof Spirit at 60° F. after Sikes.
60.	.8956	626.92	376.15	763.92	118.64
61.	.8932	625.24	381.40	774.59	120.30
62.	.8908	623.56	386.61	785.17	121.94
63.	.8886	622.02	391.87	795.85	123.60
64.	.8863	620.41	397.06	806.39	125.24
65.	.8840	618.80	402.22	816.87	126.86
66.	.8816	617.12	407.30	827.19	128.47
67.	.8793	615.51	412.39	837.52	130.07
68.	.8769	613.83	417.40	847.70	131.65
69.	.8745	612.15	422.38	857.81	133.22
70.	.8721	610.47	427.33	867.86	134.78
71.	.8696	608.72	432.19	877.73	136.32
72.	.8672	607.04	437.07	887.65	137.86
73.	.8649	605.43	441.96	897.58	139.40
74.	.8625	603.75	446.78	907.37	140.92
75.	.8603	602.21	451.66	917.28	142.46
76.	.8581	600.67	456.51	927.13	143.99
77.	.8557	598.99	461.22	936.69	145.47
78.	.8533	597.31	465.90	946.20	146.95
79.	.8508	595.56	470.49	955.52	148.40
80.	.8483	593.81	475.05	964.78	149.84
81.	.8459	592.13	479.63	974.08	151.28
82.	.8434	590.38	484.11	983.18	152.69
83.	.8408	588.56	488.50	992.09	154.08
84.	.8382	586.74	492.86	1000.95	155.45
85.	.8357	584.99	497.24	1009.84	156.83
86.	.8331	583.17	501.53	1018.56	158.19
87.	.8305	581.35	505.77	1027.17	159.53
88.	.8279	579.53	509.99	1035.74	160.86
89.	.8254	577.78	514.22	1044.33	162.20
89.154	.8250	577.50	514.69	1045.28	162.34
90.	.8228	575.96	518.36	1052.74	163.49
91.	.8199	573.93	522.28	1060.70	164.73
1	2	3	4	5	6

TABLE IV.—Diluted Alcohol from 0 to 100 per Cent.—*continued*.

1	2	3	4	5	6
Absolute Alcohol per Cent. by Weight.	Specific Gravity of the Diluted Alcohol at 60° F.	Weight in Grains of 100 Septems of the Diluted Alcohol.	Weight in Grains of the Absolute Alcohol in 100 Septems.	Equivalent of Proof Spirit in Grains.	Per Centage of Proof Spirit at 60° F. after Sikes.
92.	.8172	572.04	526.28	1068.82	165.99
93.	.8145	570.15	530.24	1076.86	167.24
94.	.8118	568.26	534.16	1084.83	168.48
95.	.8089	566.23	537.92	1092.46	169.67
96.	.8061	564.27	541.70	1100.14	170.86
97.	.8031	562.17	545.30	1107.45	171.99
98.	.8001	560.07	548.87	1114.70	173.12
99.	.7969	557.83	552.25	1121.56	174.19
100.	.7938	555.66	555.66	1128.49	175.25
1	2	3	4	5	6

TABLE V.—PER-CENTAGE OF ABSOLUTE ALCOHOL BY VOLUME. ACCORDING TO TRALLES AND GAY-LUSSAC, COMPARED WITH PER-CENTAGE OF PROOF-SPIRIT ACCORDING TO SIKES. See pages 33 to 36.

33. In France, alcohol is valued, not by *weight*, but by *volume*, according to the indications of the alcoholometer of GAY-LUSSAC, and in Prussia it is valued by volume according to the alcoholometer of TRALLES. The alcoholometer of GAY-LUSSAC has been adopted by the governments of Belgium and Sweden, and that of TRALLES by the United States of America; and as the per-centage of alcohol contained in wines and spirits is frequently referred to as the *Per-centage by Volume*, it is proper to explain the relations which this system bears to the system of reckoning the *Per-centage by Weight*, more especially as in commercial transactions with continental wine-dealers the per-centage of alcohol in wines by volume, according to the scales of Tralles and Gay-Lussac, must necessarily be commonly cited.

34. *Column 1.*—The alcoholometers of Tralles and Gay-Lussac are glass spindles having a scale from 0° to 100°, each degree indicating *one per cent.* by VOLUME of absolute alcohol contained in the mixtures submitted to trial.

35. *Column 4.*—Tralles gave with his instrument a Table of the specific gravities which corresponded with the hundred degrees of his scale. This is copied into column 4 of Table V. In regard to this

[*Continued at page 36.*]

TABLE V.—Per-Centage of ABSOLUTE ALCOHOL by VOLUME, according to TRALLES and GAY-LUSSAC, compared with Per-Centage of PROOF-SPIRIT according to SIKES.

1	2	3	4	5	6
Per-Centage of Absolute Alcohol by Volume.	Weight in Grains of 100 Septems of the Spirit at 60° F.	Specific Gravity at 60° F. Water = 1.0000 at 60° F.	Specific Gravity at 60° F. Water = .9991 at 60° F. TRALLES.	Specific Gravity at 59° F. Water = 1.0000 at 59° F. GAY-LUSSAC.	Per-Centage of Proof-Spirit, according to SIKES, at 60° F.
0	700.00	1.0000	.9991	1.0000	0.00
1	698.95	.99850	.9976	.9985	1.7525
2	697.90	.99700	.9961	.9970	3.5050
3	696.92	.99560	.9947	.9956	5.2575
4	695.93	.99419	.9933	.9942	7.0100
5	694.95	.99279	.9919	.9929	8.7625
6	694.04	.99149	.9906	.9916	10.515
7	693.13	.99019	.9893	.9903	12.268
8	692.30	.98900	.9881	.9891	14.020
9	691.45	.98779	.9869	.9878	15.773
10	690.61	.98659	.9857	.9867	17.525
11	689.77	.98539	.9845	.9855	19.278
12	689.00	.98429	.9834	.9844	21.030
13	688.23	.98318	.9823	.9833	22.783
14	687.46	.98208	.9812	.9822	24.535
15	686.76	.98108	.9802	.9812	26.288
16	685.99	.97998	.9791	.9802	28.040
17	685.29	.97898	.9781	.9792	29.793
18	684.59	.97798	.9771	.9782	31.545
19	683.89	.97698	.9761	.9773	33.298
20	683.19	.97598	.9751	.9763	35.050
21	682.49	.97498	.9741	.9753	36.803
22	681.79	.97398	.9731	.9742	38.555
23	681.01	.97287	.9720	.9732	40.308
24	680.31	.97187	.9710	.9721	42.060
25	679.61	.97087	.9700	.9711	43.813
26	678.84	.96977	.9689	.9700	45.565
27	678.14	.96877	.9679	.9690	47.318
28	677.37	.96767	.9668	.9679	49.070
29	676.60	.96657	.9657	.9668	50.823
1	2	3	4	5	6

TABLE V.—Per-Centage of Alcohol by Volume, &c.—*continued.*

1	2	3	4	5	6
Per-Centage of Absolute Alcohol by Volume.	Weight in Grains of 100 Septems of the Spirit at 60° F.	Specific Gravity at 60° F. Water = 1.0000 at 60° F.	Specific Gravity at 60° F. Water = .9991 at 60° F. TRALLÉS.	Specific Gravity at 59° F. Water = 1.0000 at 59° F. GAY-LUSSAC.	Per-Centage of Proof-Spirit, according to SIKES, at 60 F.
30	675.83	.96547	.9646	.9657	52.575
31	674.99	.96427	.9634	.9645	54.328
32	674.15	.96307	.9622	.9633	56.080
33	673.23	.96176	.9609	.9621	57.833*
34	672.32	.96046	.9596	.9608	59.585
35	671.41	.95916	.9583	.9594	61.338
36	670.50	.95786	.9570	.9581	63.090
37	669.52	.95646	.9556	.9567	64.843
38	668.47	.95496	.9541	.9553	66.595
39	667.42	.95346	.9526	.9538	68.348
40	666.30	.95186	.9510	.9523	70.100
41	665.18	.95025	.9494	.9507	71.853
42	664.06	.94865	.9478	.9491	73.605
43	662.87	.94695	.9461	.9474	75.358
44	661.68	.94525	.9444	.9457	77.110
45	660.49	.94355	.9427	.9440	78.863
46	659.23	.94175	.9409	.9422	80.615
47	657.97	.93995	.9391	.9404	82.368
48	656.70	.93814	.9373	.9386	84.120
49	655.37	.93624	.9354	.9367	85.873
50	654.04	.93434	.9335	.9348	87.625
51	652.64	.93234	.9315	.9329	89.378
52	651.24	.93034	.9295	.9309	91.130
53	649.83	.92833	.9275	.9289	92.883
54	648.36	.92623	.9254	.9269	94.635
55	646.96	.92423	.9234	.9248	96.388
56	645.49	.92213	.9213	.9227	98.140
57	644.02	.92003	.9192	.9206	99.893
57.06	643.89	.91984	SIKES'S PROOF-SPIRIT.		100.00
58	642.48	.91783	.9170	.9185	101.65
1	2	3	4	5	6

TABLE V.—Per-Centage of Alcohol by Volume, &c.—*continued*.

1	2	3	4	5	6
Per-Centage of Absolute Alcohol by Volume.	Weight in Grains of 100 Septems of the Spirit at 60° F.	Specific Gravity at 60° F. Water = 1.0000 at 60° F.	Specific Gravity at 60° F. Water = .9991 at 60° F. TRALLS.	Specific Gravity at 59° F. Water = 1.0000 at 59° F. GAY-LUSSAC.	Per-Centage of Proof-Spirit, according to SIKES, at 60° F.
59	640.93	.91562	.9148	.9163	103.40
60	639.39	.91342	.9126	.9141	105.15
61	637.85	.91112	.9104	.9119	106.90
62	636.31	.90902	.9082	.9096	108.66
63	634.70	.90672	.9059	.9073	110.41
64	633.09	.90441	.9036	.9050	112.16
65	631.48	.90211	.9013	.9027	113.91
66	629.80	.89971	.8989	.9004	115.67
67	628.12	.89731	.8965	.8980	117.42
68	626.43	.89490	.8941	.8956	119.17
69	624.75	.89250	.8917	.8932	120.92
70	623.00	.89000	.8892	.8907	122.68
71	621.25	.88750	.8867	.8882	124.43
72	619.50	.88500	.8842	.8857	126.18
73	617.74	.88249	.8817	.8831	127.93
74	615.92	.87989	.8791	.8805	129.69
75	614.10	.87729	.8765	.8779	131.44
76	612.28	.87469	.8739	.8753	133.19
77	610.39	.87198	.8712	.8726	134.94
78	608.50	.86928	.8685	.8699	136.70
79	606.61	.86658	.8658	.8672	138.45
80	604.72	.86388	.8631	.8645	140.20
81	602.75	.86107	.8603	.8617	141.95
82	600.79	.85827	.8575	.8589	143.71
83	598.83	.85547	.8547	.8560	145.46
84	596.80	.85257	.8518	.8531	147.21
85	594.69	.84956	.8488	.8502	148.96
86	592.59	.84656	.8458	.8472	150.72
87	590.49	.84356	.8428	.8442	152.47
88	588.32	.84046	.8397	.8411	154.22
89	586.08	.83725	.8365	.8379	155.97
90	583.77	.83395	.8332	.8346	157.73
91	581.46	.83065	.8299	.8312	159.48
1	2	3	4	5	6

TABLE V.—Per-Centage of Alcohol by Volume, &c.—*continued*.

1	2	3	4	5	6
Per-Centage of Absolute Alcohol by Volume.	Weight in Grains of 100 Septems of the Spirit at 60° F.	Specific Gravity at 60° F. Water = 1.0000 at 60° F.	Specific Gravity at 60° F. Water = .9991 at 60° F. TRALLÉS.	Specific Gravity at 59° F. Water = 1.0000 at 59° F. GAY-LUSSAC.	Per-Centage of Proof-Spirit, according to SIKES, at 60° F.
92	579.07	.82724	.8265	.8278	161.23
92.63	577.50	.82500	GILPIN'S ALCOHOL.		162.34
93	576.62	.82374	.8230	.8242	162.98
94	574.10	.82014	.8194	.8206	164.74
95	571.50	.81643	.8157	.8168	166.49
96	568.77	.81253	.8118	.8128	168.24
97	565.90	.80843	.8077	.8086	169.99
98	562.88	.80412	.8034	.8042	171.75
99	559.66	.79952	.7988	.8096	173.50
100	556.23	.79461	.7939	.7947	175.25
1	2	3	4	5	6

Table, it is to be remarked, that while the diluted alcohols are all supposed to be weighed at 60° Fahr., the water taken as a standard of comparison is supposed to be weighed as unity at about 40° Fahr., so that at 60° Fahr. its density comes to be only .9991, instead of 1.0000.

36. *Column 3.*—As this peculiarity constitutes an inconvenient puzzle to most practical men, I have recalculated these specific gravities to suit the standard of water when that is taken as unity at the same temperature as that at which the diluted alcohols are to be weighed, and I have given these numbers in column 3 of Table V.

37. *Column 2.*—From the numbers in column 3, those in column 2 have been deduced. These numbers, expressing the weight of a centigallon of each diluted alcohol, are of the same value as the numbers printed in column 3 of Tables III. and IV. Consequently, if a diluted alcohol is weighed in the specific gravity bottle, Fig. 1, page 14, the resulting weight in grains may be sought for in Tables III., IV., or V., according as it may be desired to express the result as per-centage of alcohol by weight, or by volume. In either case, the numbers in column 6 of the Tables indicate the per-centage according to SIKES.

38. *Column 6.*—Upon referring to the last line of Table V., which represents spirit that contains 100 per cent. of absolute alcohol by

volume, it will be seen in column 6 that this is equal to 175.25 per cent. of proof-spirit. On dividing this number by 100, we have 1.7525 as the value of 1 per cent. of absolute alcohol by volume expressed in terms of Sikes's scale. Consequently, when the percentage of absolute alcohol by volume in any mixture is known (or found by experiment), on multiplying that percentage by 1.7525 you find the percentage of proof-spirit according to Sikes. On the other hand, when the percentage according to Sikes is known, on dividing that percentage by 1.7525, you find the percentage of absolute alcohol by volume. Thus, if we have a liquor of 26° of Sikes, and want to know the corresponding degree of Gay-Lussac or of Tralles, we divide 26 by 1.7525, and find the product to be 14.836:

$$\frac{26.0000}{1.7525} = 14.836$$

39. Column 5.—The numbers in this column represent the specific gravities of the spirits that correspond to the hundred degrees of Gay-Lussac's alcoholometer.

TABLE VI.—COMPARISON of GAY-LUSSAC'S NUMBERS with those of TRALLES.

1 Alcohol per Cent. by Volume.	2 Specific Gravity at 59° GAY-LUSSAC.	3 Specific Gravity at 59° TRALLES, corrected.	4 Differences between Columns 2 and 3.
30	.96570	.96555	.00015
35	.95940	.95924	.00016
40	.95230	.95194	.00036
45	.94400	.94363	.00037
50	.93480	.93441	.00039
55	.92480	.92430	.00050
60	.91410	.91349	.00061
65	.90270	.90218	.00052
70	.89070	.89007	.00063
75	.87790	.87736	.00054
80	.86450	.86395	.00055
85	.85020	.84963	.00057
90	.83460	.83402	.00058
95	.81680	.81650	.00030
100	.79470	.79467	.00003
1	2	3	4

40. Columns 1 and 2 of Table VI. contain numbers which were originally published by Berzelius, in the first Paris edition of his "System of Chemistry," but it was not then stated that they were authorised by Gay-Lussac. They agree, however, with the numbers given in column 5 of Table V., which were originally published so recently as 1851, on the authority of the instrument-maker, Collardeau, and presented by him to the French Academy of Science, as the numbers of Gay-Lussac's original Table, according to which the alcoholometers were first graduated.

41. The numbers given in column 3 of Table VI. are the numbers of Tralles, corrected, first, to agree with water taken as unity at 59° Fahr.; and, secondly, reduced from the temperature of 60° Fahr. to that of 59° Fahr. Column 4 shows the differences between Gay-Lussac's numbers and these corrected numbers of Tralles; and from a comparison of these numbers, it may be safely concluded, that for practical purposes the alcoholometers of Gay-Lussac and of Tralles are identical; save that Tralles's instrument is graduated at 60° Fahr., and that of Gay-Lussac at 59° Fahr. Hence, the weights and specific gravities which are given in columns 2 and 3 of Table V. are correct as regards the scales of these two alcoholometers; so that, whether you take the specific gravity of a mixture of alcohol and water by Tralles's spindle, or by that of Gay-Lussac, or by a spindle the scale of which marks water as 1.0000, or by weighing the liquor in a specific gravity bottle, you can in all these cases find, on referring to this Table, any equivalent particular, such as the per-centage of proof-spirit according to Sikes, the per-centage of alcohol by volume, &c.

42. In the preceding pages I have recommended the estimation of the strength of alcoholic liquors to be made by weighing the liquors in a bottle, and not by using alcoholometers. The latter are handy to use, but liable to some inconveniences. If made of metal, they are subject to injury by blows, and then give false indications. The glass instruments are broken by blows, and are less subject to give false intimations when in true hands. But the following particulars deserve notice. The Minister of Agriculture, Commerce, and Public Works in France, inquired of the Academy of Science whether the degrees of Gay-Lussac's alcoholometer could not be so ascertained and fixed that the instruments could be stamped by the State, as weights and measures are stamped? The Report of the Commissioners, who comprised MM. CHEVREUL, DESPRETZ, FREMY, and POUILLET, stated that stamping was inexpedient for these reasons:—The theory of the instrument was perfect, but the manufacture of it presented difficulties that rendered the instruments only comparable within certain limits of tolerance. The graduation of the instrument becomes in time less accurate than when it is first made. The instruments can be altered by fraudulent persons, so as to make their indications stronger or weaker, to suit the

purposes of an unfair buyer or seller of spirits. Fraudulent instruments could with difficulty be seized to be used as evidence against their possessors, because they could be instantly destroyed by merely letting them fall. Considering therefore that a stamped instrument could be rendered fraudulent after the stamping, it is evident that the stamping could be used to cover a fraud, and it ought not on that account to be practised.

All persons who use glass hydrometers should, for these reasons, occasionally test their accuracy by determining with the weighing bottle whether the degrees indicated by the hydrometers are correct.

TABLE VII.—For the DILUTION of SPIRITS, and for the VALUATION of PROOF-SPIRIT, according to SIKES. See pages 40 to 42.

43. *Column 1* of Table VII. shows the Degree of PROOF-SPIRIT according to Sikes.

Column 2 shows the amount of UNDER-PROOF according to Sikes, from $99\frac{1}{2}$ U.P. to 1 U.P., and the amount of OVER-PROOF from 1 O.P. to $75\frac{1}{2}$ O.P., the latter being the strongest spirit possible at 60° Fahr.

Column 3 shows the VOLUMES of all these spirits which are equivalent to one another—that is to say, the volumes or measures of every spirit that contain 100 volumes or measures of proof-spirit.

The following PROBLEMS show some of the uses of the numbers in this Table:—

44. *What quantity of Proof-Spirit (or of spirit of any other strength) is contained in 100 gallons of 20 per cent. O.P.?*

The equivalent number of 20 O.P. is $83\cdot333$, and that of Proof is $100\cdot000$. We have, therefore, the following calculation to perform, in order to find the answer to this question:—

$$83\cdot333 : 100\cdot000 = 100 : x$$

$$x = 120.$$

For spirits of other strengths the equations are these:—

$$\text{For 40 U.P. } 83\cdot333 : 166\cdot670 = 100 : 200.$$

$$\text{For 60 U.P. } 83\cdot333 : 250\cdot000 = 100 : 300.$$

$$\text{For 50 O.P. } 83\cdot333 : 66\cdot667 = 100 : 80.$$

$$\text{For 60 O.P. } 83\cdot333 : 62\cdot500 = 100 : 75.$$

45. *It is assumed that you require 120 gallons of spirits of 17 per cent. U.P. How much must be taken for that purpose of spirits that are respectively 10 U.P.; 5 U.P.; 30 O.P.; and 66 O.P.?*

The equivalent volumes of these per-centages are as follow (see the Table):—

$$17 \text{ U.P.} = 120\cdot48$$

$$10 \text{ U.P.} = 111\cdot11$$

$$5 \text{ U.P.} = 105\cdot26$$

$$30 \text{ O.P.} = 76\cdot923$$

$$66 \text{ O.P.} = 60\cdot241$$

[Continued at page 42.]

TABLE VII.—For the DILUTION of SPIRITS, and for the VALUATION of PROOF-SPIRIT, according to SIKES.

1	2	3	1	2	3
Degree, according to Sikes, at 60° F.	Under Proof, according to Sikes.	Equivalent Volume.	Degree, according to Sikes, at 60° F.	Under Proof, according to Sikes.	Equivalent Volume.
1	99	10000.	34	66	294.12
2	98	5000.0	35	65	285.71
3	97	3333.3	36	64	277.78
4	96	2500.0	37	63	270.27
5	95	2000.0	38	62	263.86
6	94	1666.7	39	61	256.41
7	93	1428.6	40	60	250.00
8	92	1250.0	41	59	243.90
9	91	1111.1	42	58	238.10
10	90	1000.0	43	57	232.56
11	89	909.09	44	56	227.27
12	88	833.33	45	55	222.22
13	87	769.23	46	54	217.39
14	86	714.29	47	53	212.77
15	85	666.67	48	52	208.33
16	84	625.00	49	51	204.08
17	83	588.24	50	50	200.00
18	82	555.56	51	49	196.08
19	81	526.32	52	48	192.31
20	80	500.00	53	47	188.68
21	79	476.19	54	46	185.19
22	78	454.54	55	45	181.82
23	77	434.78	56	44	178.57
24	76	416.67	57	43	175.44
25	75	400.00	58	42	172.41
26	74	384.62	59	41	169.49
27	73	370.37	60	40	166.67
28	72	357.14	61	39	163.93
29	71	344.83	62	38	161.29
30	70	333.33	63	37	158.73
31	69	322.58	64	36	156.25
32	68	312.50	65	35	153.85
33	67	303.03	66	34	151.52
1	2	3	1	2	3

TABLE VII.—For the Dilution of Spirits, &c.—*continued*

1	2	3	1	2	3
Degree, according to Sikes, at 60° F.	Under Proof, according to Sikes.	Equivalent Volume.	Degree, according to Sikes, at 60° F.	Over Proof, according to Sikes.	Equivalent Volume.
67	33	149.25		OVER- PROOF.	
68	32	147.06			
69	31	144.93	101	1	99.010
70	30	142.86	102	2	98.039
71	29	140.85	103	3	97.087
72	28	138.89	104	4	96.154
73	27	136.99	105	5	95.238
74	26	135.14	106	6	94.340
75	25	133.33	107	7	93.458
76	24	131.58	108	8	92.593
77	23	129.87	109	9	91.743
78	22	128.21	110	10	90.909
79	21	126.58	111	11	90.090
80	20	125.00	112	12	89.286
81	19	123.46	113	13	88.496
82	18	121.95	114	14	87.719
83	17	120.48	115	15	86.957
84	16	119.05	116	16	86.207
85	15	117.65	117	17	85.470
86	14	116.28	118	18	84.746
87	13	114.94	119	19	84.034
88	12	113.64	120	20	83.333
89	11	112.36	121	21	82.645
90	10	111.11	122	22	81.967
91	9	109.89	123	23	81.301
92	8	108.70	124	24	80.645
93	7	107.53	125	25	80.000
94	6	106.38	126	26	79.365
95	5	105.26	127	27	78.740
96	4	104.17	128	28	78.125
97	3	103.09	129	29	77.519
98	2	102.04	130	30	76.923
99	1	101.01	131	31	76.336
	—	—	132	32	75.758
100	PROOF.	100.00	133	33	75.188
1	2	3	1	2	3

TABLE VII.—For the Dilution of Spirits, &c.—*continued*.

1 Degree, according to Sikes, at 60° F.	2 Over Proof, according to Sikes.	3 Equivalent Volume.	1 Degree, according to Sikes, at 60° F.	2 Over Proof, according to Sikes.	3 Equivalent Volume.
	OVER- PROOF.			OVER- PROOF.	
134	34	74.627	156	56	64.103
135	35	74.074	157	57	63.694
136	36	73.529	158	58	63.291
137	37	72.993	159	59	62.893
138	38	72.464	160	60	62.500
139	39	71.942	161	61	62.112
140	40	71.429	162	62	61.728
141	41	70.922	163	63	61.350
142	42	70.423	164	64	60.976
143	43	69.930	165	65	60.606
144	44	69.444	166	66	60.241
145	45	68.966	167	67	59.880
146	46	68.493	168	68	59.524
147	47	68.027	169	69	59.172
148	48	67.568	170	70	58.824
149	49	67.114	171	71	58.480
150	50	66.667	172	72	58.140
151	51	66.225	173	73	57.803
152	52	65.789	174	74	57.471
153	53	65.359	175	75	57.143
154	54	64.935	175½	75½	57.061
155	55	64.516			
1	2	3	1	2	3

We have consequently to perform the following calculations to bring out the answers to the question proposed:—

$$\begin{aligned}
 120.48 : 120 &= 111.11 : 110.7 \\
 120.48 : 120 &= 105.26 : 104.84 \\
 120.480 : 120 &= 76.923 : 76.61 \\
 120.480 : 120 &= 60.241 : 60.
 \end{aligned}$$

46. If Proof-Spirit is worth 15s. per gallon, what is the value per gallon of spirits of the following per-centages, namely, 20 O.P.; 40 O.P.; 60 O.P.; 20 U.P.; 40 U.P.; and 60 U.P.?

In this case, we make use of the numbers given in column 1 of Table VII., namely, those which represent the degree or per-centage according to Sikes, 100 being the number for proof-spirit and representing the value of 15s. Hence we say:—

$$\text{For 20 O.P. } 100 : 15s. = 120 : 18s.$$

$$\text{For 40 O.P. } 100 : 15s. = 140 : 21s.$$

$$\text{For 60 O.P. } 100 : 15s. = 160 : 24s.$$

$$\text{For 20 U.P. } 100 : 15s. = 80 : 12s.$$

$$\text{For 40 U.P. } 100 : 15s. = 60 : 9s.$$

$$\text{For 60 U.P. } 100 : 15s. = 40 : 6s.$$

47. Suppose Spirit of 20 per cent. O.P. to be worth 20s. per gallon, what is the value per gallon of Spirit of 50 per cent. O.P.?

$$120 : 20s. = 150 : 25s.$$

48. Suppose Spirit of 10 per cent. U.P. to be worth 9s. per gallon, what is the value of Spirit of 10 per cent. O.P.?

$$90 : 9s. = 110 : 11s.$$

49. Given the gauged contents of a quantity of spirit, and its degree according to Sikes (as expressed in column 1 of Table VII.), to find the total Quantity of Proof-Spirit.

Example 1.—Suppose the gauged contents to be 132 gallons and the degree to be 122.5, or 22.5 Over Proof.

Multiply 132 by 100, and divide the product by the equivalent volume of the spirit of 122.5. That number is not contained in the Table, but is found by taking the mean of the two nearest equivalent numbers 122 and 123; which mean is 81.634. The reckoning is therefore—

$$\frac{132 \times 100}{81.634} = 161.7 \text{ gallons of proof-spirit.}$$

This reckoning is founded on the following equation:—

$$\begin{array}{ccccc} \text{The equivalent} & : & 100, & = & \text{the gauged} & : & \text{gallons of} \\ \text{volume} & \text{or the volume} & & & \text{gallons} & & \text{proof-spirit.} \\ & \text{of proof} & & & & & \end{array}$$

The reckoning may be abridged by omitting the multiplication by 100, and removing the decimal point of the divisor two places to the left, thus:—

$$\frac{132}{.81634} = 161.7.$$

Example 2.—Gauged contents 3675 gallons.

Degree 24 per cent. Under Proof.

$$\frac{3675}{1.3158} = 2793 \text{ gallons of proof-spirit.}$$

50. *Results obtained by another method. Example 1.*—Multiply 132 by the per-centage of Over Proof after removing the decimal point two places to the left. Add the product to 132. The result is the desired quantity.

$$132 \times .225 = 29.7. \text{ And } 132 + 29.7 = 161.7.$$

Example 2.—Multiply 3675 by the per-centage of Under Proof, after removing the decimal point two places to the left. Deduct the product from 3675. The remainder is the desired quantity.

$$3675 \times .24 = 882. \text{ And } 3675 - 882 = 2793.$$

51. *To find what quantity of 7 per cent. Over Proof is contained in 2360 gallons of 8 per cent. Over Proof.*

Either of the following methods of calculation may be used. They both give the same result, 2382 gallons.

$$\text{I. } \begin{array}{r} .93458 \times 2360 \\ \hline .92593 \end{array} = 2382.$$

$$\text{II. } \frac{108 \times 2360}{107} = 2382.$$

MISCELLANEOUS PROBLEMS.

To convert Per-Centage of Absolute Alcohol by Weight into Per-Centage by Volume.

52. *First Method.*—Multiply the specific gravity of the mixture by the per-centage by weight, and divide the product by .7938. The product of the division is the per-centage by volume.

Example.—The per cent. by Weight of alcohol in a given Spirit is 20. What is the per cent. by Volume?

The specific gravity (see Table IV.) is .9716. Then

$$\frac{.9716 \times 20}{.7938} = 24.48.$$

53. *Second Method.*—Multiply the weight in grains of a centigallon of the mixture by the per-centage of alcohol by weight, and divide the product by 555.66. The product of the division is the per-centage by volume.

Example.—The same as above. The weight in grains of a centigallon of the given spirit (see Table IV.) is 680.12. Then

$$\frac{680.12 \times 20}{555.66} = 24.48.$$

54. *Third Method.*—The same example. Look into Table IV. for the specific gravity of the spirit that is given as having 20 per cent. of alcohol by weight. This is found to be .9716. Then look for this

specific gravity in Table V., and against the specific gravity in that Table will be found in column 1 the per-centage of alcohol by volume. When, as in this example, the specific gravity is not found in Table V., you can still, by observing the adjacent numbers, come very readily to a result within $\frac{1}{4}$ per cent. of the truth; or you can arrive at a precise result by the method of interpolation described at page 27. But the first*and second methods are to be preferred.

To convert Per-Centage of Absolute Alcohol by Volume into Per-Centage by Weight.

55. *First Method.*—Divide $\cdot 79461$ by the specific gravity of the mixture, and multiply the product by the per-centage by volume. The result is the per-centage by weight.

Example.—The per-centage of alcohol by volume in a given mixture is 50. Required, the per-centage by weight.

At article 50, in Table V., you find specific gravity $\cdot 93434$. Then

$$\frac{\cdot 79461}{\cdot 93434} = \cdot 85045,$$

and $\cdot 85045 \times 50 = 42\cdot 52250$, which is the required per-centage by weight.

56. *Second Method.*—Divide $556\cdot 23$ by the weight in grains of a centigallon of the mixture, and multiply the product by the per-centage by volume.

Example.—The same as above.

The weight in grains of a centigallon of alcohol of 50° (see Table V., column 2) is $654\cdot 04$. Then

$$\frac{556\cdot 23}{654\cdot 04} = \cdot 85045,$$

$$\text{and } \cdot 85045 \times 50 = 42\cdot 52250.$$

57. *Third Method.*—The same example. Look into Table V. for the specific gravity of alcohol of 50 per cent. by volume. Then look into Table IV. for the same specific gravity, against which you find, in column 1, the per-centage by weight. In this case, the specific gravity found in Table V. is $\cdot 93434$; which specific gravity is not contained in Table IV., but the nearest numbers are $\cdot 9356$ and $\cdot 9335$, which show that the required per-centage by weight is very close upon $42\frac{1}{2}$. The first and second methods give the number exactly.

57a. *To Convert Grains of Absolute Alcohol contained in a Centigallon of Spirits into Per-Centage of Absolute Alcohol by Volume.*

Divide the number of grains of absolute alcohol contained in a centigallon of spirit by $5\cdot 5566$. The product is the per-centage of absolute alcohol by volume.

Example.—Grains of absolute alcohol in 100 septems of Port, No. 1, in Table I. = 141.68.

$$\frac{141.8600}{5.5566} = 25.53.$$

58. To convert Per-Centage of Absolute Alcohol by Volume into Grains of Absolute Alcohol in 100 Septems of Spirits.

Multiply the per-centage by 5.5566. The product is grains of absolute alcohol in 100 septems.

Example.—50°. $5.5566 \times 50 = 277.83.$

59. To convert Per-Centage of Absolute Alcohol by Volume into Grains of Proof-Spirit in 100 Septems of Spirits.

Multiply the per-centage by 11.285. The product is grains of proof-spirit in 100 septems.

Example.—50°. $11.285 \times 50 = 564.25.$

60. To convert Per-Centage of Absolute Alcohol by Volume into Per-Centage of Proof-Spirit after Sikes.

Multiply the per-centage of absolute alcohol by volume by 1.7525. The product is the per-centage of proof-spirit after Sikes.

61. To convert the Per-Centage of Proof-Spirit after Sikes into Per-Centage of Absolute Alcohol by Volume.

Divide the per-centage after Sikes by 1.7525. The product is the per-centage of absolute alcohol by volume.

62. To convert the Per-Centage of Proof-Spirit after Sikes into Grains of Proof-Spirit in 100 Septems.

Multiply the per-centage after Sikes by 6.4389. The product is grains of proof-spirit in 100 septems.

63. To convert the Per-Centage of Proof-Spirit after Sikes into Grains of Absolute Alcohol in 100 Septems.

Multiply the per-centage after Sikes by 3.1705. The product is grains of absolute alcohol in 100 septems.

CORRECTION FOR TEMPERATURE, REQUIRED BY EXPERIMENTS MADE WITH ALCOHOLOMETERS.

64. In calculating the preceding Tables, and in making the comparisons of different alcoholometers with one another, the temperature of 60° Fahrenheit is laid down as a constant basis. But since alcohol in all its stages of dilution changes its volume greatly with change of temperature, it is in every experiment necessary to observe strictly the temperature of the liquid at the moment of operation. In experiments with small quantities of spirits, such as those which are submitted to trial in the testing of wines, the operator has it in his power to control the temperature, and can readily raise or lower the liquor to 60° F.

But when large quantities of spirits are under trial, the experiment is often made on portions at temperatures that differ from the normal temperature at which excise and other valuations are made. In that case, Tables of Corrections, prepared for the purpose, are used with each form of alcoholometer. Thus, in Britain, a book of Tables accompanies the alcoholometer of Sikes, and in France a set of Tables is used with the alcoholometer of Gay-Lussac. It is of course impossible to incorporate bulky tables of corrections for all temperatures in a work of this kind, and I must refer those who require them to the several special publications.

65. I will, however, give here an account of a method of *calculating* the effects of change of temperature upon mixtures that are tested with these alcoholometers which indicate the per-centage of alcohol by volume, as illustrated by Table V. The results of these calculations are not quite accurate, but they often give close approximations to the truth, and as they can be made readily, without reference to books, they may sometimes prove useful to practical men. The results are most accurate for spirits that contain above 25 per cent. of alcohol by volume. They are not to be trusted for weak spirits. As for temperatures, the calculations may be made for all degrees between 40° and 85° of Fahrenheit.

CALCULATION TO BE MADE WHEN GAY-LUSSAC'S ALCOHOLOMETER IS USED. Normal Temperature 59° F.

66. Observe the per-centage of alcohol as indicated by the Alcoholometer, and the temperature of the mixture as indicated by Fahrenheit's Thermometer. Multiply by $\cdot 222$ the *difference* between 59° and the temperature found by trial. If the observed temperature is *above* 59° , Deduct the product of this multiplication from the per-centage indicated by the Alcoholometer. If the observed temperature is *below* 59° , Add the product of the multiplication to the per-centage indicated by the Alcoholometer. The final product is the per-centage of alcohol by volume at 59° F.

Example 1.—A spirituous mixture at the temperature of 77° Fahr. is found to indicate 60 per cent. of alcohol by volume. What is the per-centage at 59° Fahr.?

$$77^{\circ} - 59^{\circ} = 18^{\circ}. \text{ And } 18 \times \cdot 222 = 3\cdot 996,$$

which may be called 4.

$$60 - 4 = 56 \text{ per cent. of Alcohol at } 59^{\circ} \text{ Fahr}$$

Example 2.—Another spirit marks 75 per cent. of alcohol at 45° Fahr. What is the per-centage at 59° Fahr.?

$$59^{\circ} - 45^{\circ} = 14^{\circ}. \text{ And } 14 \times \cdot 222 = 3\cdot 108.$$

$$75 + 3\cdot 1 = 78\cdot 1 \text{ per cent. of alcohol at } 59^{\circ} \text{ Fahr.}$$

Example 3.—A spirit marks 80 per cent. at 59° Fahr. What will it mark at 85° Fahr.?

$$\begin{aligned} 85^{\circ} - 59^{\circ} &= 26^{\circ}. \text{ And } 26 \times .222 = 5.772. \\ 80 + 5.8 &= 85.8 \text{ per cent. of alcohol at } 85^{\circ} \text{ Fahr.} \end{aligned}$$

CALCULATION TO BE MADE WHEN TRALLÉS'S ALCOHOLOMETER IS USED.
Normal temperature 60° Fahr.

67. The calculations are the same as those just described, with the difference that the normal temperature is in this case 60° Fahr. and not 59° . An example or two will make the process clear.

Example 4.—A spirit at 80° Fahr. marks 89 per cent. of alcohol. What will it mark at 60° Fahr.?

$$\begin{aligned} 80^{\circ} - 60^{\circ} &= 20^{\circ}. \text{ And } 20 \times .222 = 4.440. \\ 89 - 4.5 &= 84.5 \text{ per cent. of alcohol at } 60^{\circ} \text{ Fahr.} \end{aligned}$$

Example 5.—Proof-spirit at 60° Fahr. marks 57.06 per cent. of alcohol by volume. What will it mark at 84° Fahr.?

$$\begin{aligned} 84^{\circ} - 60^{\circ} &= 24^{\circ}. \text{ And } 24 \times .222 = 5.328. \\ 57.06 + 5.33 &= 62.39 \text{ per cent. of alcohol at } 84^{\circ} \text{ Fahr.} \end{aligned}$$

Example 6.—A spirit at 85° Fahr. marks 50 per cent. of alcohol. What will it mark at 60° Fahr.?

$$\begin{aligned} 85^{\circ} - 60^{\circ} &= 25^{\circ}. \text{ And } 25 \times .222 = 5.55. \\ 50 - 5.55 &= 44.45 \text{ per cent. of alcohol at } 60^{\circ} \text{ Fahr.} \end{aligned}$$

CALCULATION TO BE MADE WHEN SIKES'S HYDROMETER IS USED.
Normal temperature 60° Fahr.

68. *a.* Convert the Per-centage of Proof-Spirit according to Sikes, as found by experiment, into Per-centage of Alcohol by Volume by means of the calculation described in paragraph 61, namely, by dividing it by 1.7525 .

b. Make the correction for temperature by the calculation given at 67.

c. From the Per-centage by Volume at 60° thus determined, calculate the Per-centage according to Sikes by the method described at 60, namely, by multiplying it by 1.7525 .

Example 7.—A spirit at 75° Fahr. marks 140.20 per cent. of alcohol by Sikes's Hydrometer, or is 40.2 per cent. O.P. What is the Per-centage by Sikes at 60° Fahr.?

$$a. \frac{140.2000}{1.7525} = 80 \text{ (Per-centage by Volume at } 75^{\circ}\text{).}$$

$$\begin{aligned} b. 75^{\circ} - 60^{\circ} &= 15^{\circ}. \text{ And } 15 \times .222 = 3.330. \\ 80 - 3.33 &= 76.67 \text{ (Per-centage by Volume at } 60^{\circ}\text{).} \end{aligned}$$

$$c. 76.67 \times 1.7525 = 134.36.$$

Result.—Per-centage at 60° Fahr. = 134.36 , or 34.36 per cent. over-proof.

CALCULATION TO BE MADE WHEN THE WEIGHT OF A CENTIGALLON OF SPIRIT IS DETERMINED BY MEANS OF THE SPECIFIC GRAVITY BOTTLE, DESCRIBED IN PARAGRAPH 7. Normal temperature, 60° Fahr.

69. Look for the weight of the spirit in column 2 of Table V. and take the Per-centage of Alcohol by Volume as given in column 1 of that Table. If the observed weight of the spirit is not to be found in column 2, the per-centage must be calculated by the method described under the head of *Interpolation* in paragraph 23. Having thus found the per-centage of alcohol by volume at the observed temperature, the reduction to 60° Fahr. can be made as above described; and when the per-centage by volume at 60° is determined, any other equivalent can be determined by the calculations described among the Miscellaneous Problems given at page 44.

Example 8.—A centigallon (= 100 septems) of spirit at 80° Fahr. weighs 583.77 grains. What will be at 60° Fahr.—

- a. Its per-centage of alcohol by volume?
- b. Its per-centage of proof-spirit after Sikes?
- c. The weight in grains of proof-spirit in a centigallon?
- d. The weight in grains of absolute alcohol in a centigallon?
- e. The per-centage of alcohol by weight?

The answers to these questions are found by working the following Problems:—

a. 583.77 grains is found in column 2 of Table V. as the equivalent of 90 per cent. of alcohol by volume.

$$80^{\circ} - 60^{\circ} = 20^{\circ}. \text{ And } 20 \times .222 = 4.440.$$

$$90 - 4.44 = 85.56. \text{ This is its per-centage of alcohol by volume at } 60^{\circ}.$$

b. By Problem 60, $85.56 \times 1.7525 = 149.94$, which is the per-centage of proof-spirit after Sikes at 60° .

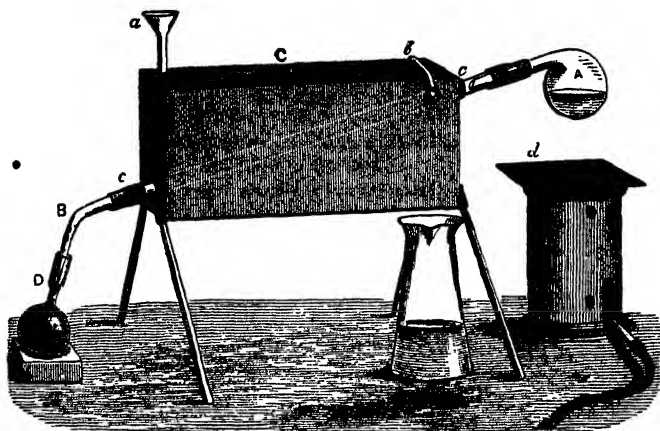
c. By Problem 59, $85.56 \times 11.285 = 965.54$, which is the weight in grains of proof-spirit contained in a centigallon of the mixture at 60° Fahr.

$$d. \text{ By Problem 58, } 85.56 \times 5.5566 = 475.42.$$

$$\text{By Problem 63, } 149.94 \times 3.1705 = 475.38.$$

The mean of these two products is 475.40 , which is the weight in grains of absolute alcohol contained in a centigallon of the mixture at 60° Fahr. The difference in the two results is due to the shortening of long lines of decimal numbers. It is of no practical importance.

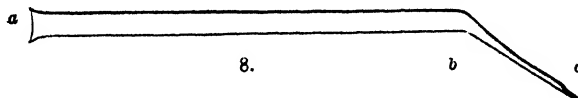
e. To find the per-centage of absolute alcohol by weight, recourse must be had to Table IV., in column 4 of which the number produced by the last calculation must be sought for. This number, however, 475.40, is not in the Table. The nearest to it is 475.05, against which, in column 1, we find the required per-centage of alcohol given as 80. This will be sufficiently exact for most purposes, but if greater precision is demanded, a calculation by the method of interpolation, see paragraph 23, will show the true per-centage by weight to be 80.08.



EXPERIMENTAL DETERMINATION OF THE QUANTITY OF ALCOHOL IN WINES.

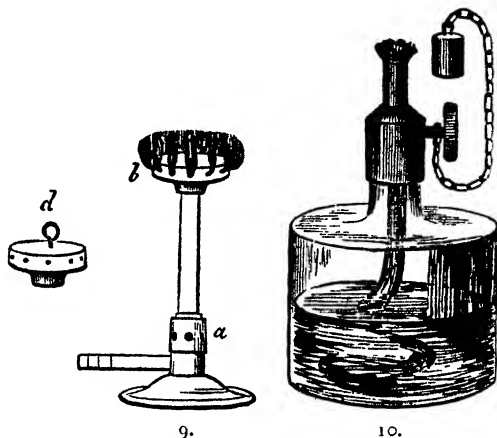
70. The most direct and most accurate method of ascertaining the quantity of alcohol contained in any wine is to separate it by distillation and weigh it. The operation is very simple, and anybody who bestows a little attention upon it will succeed perfectly in its performance.

71. The APPARATUS required for the experiment is represented by Figs. 7 to 15. It consists of the following parts:—A, Fig. 7, is a small glass still or retort, of about 4 fluid ounces or 250 septems in capacity. It is shown separately in Fig. 11. B c c is a bent glass tube which serves as a condenser. It is shown separately by Fig. 8.



From *a* to *b* it measures about 16 inches in length, and $\frac{5}{8}$ inch in diameter; the bent end, *b* to *c*, is about 4 inches long, and tapers off to a small opening. C, Fig. 7, is a reservoir of cold water. It measures 11 inches in length, 5 inches in depth, and $2\frac{1}{2}$ inches in width. It is made of copper. At one end is a funnel that reaches nearly to the bottom of the reservoir. *b* is a pipe that is fixed in the

top of the reservoir, and serves to let off warm water when cold water is poured into the funnel. The tube B is fixed in the reservoir C by means of caoutchouc collars, *cc*, which either fit tight by their elasticity, or which must be tied to the metal neck of the reservoir so as to prevent any escape of water at the joints. The bottle D is the specific gravity bottle already described at Sect. 7. The furnace E supplies the necessary heat for the distillation. It is formed of glazed stoneware. Within it is placed either a gas-burner, of the form of Fig. 9, or a spirit lamp, of the form of Fig. 10, either of which can be used to give

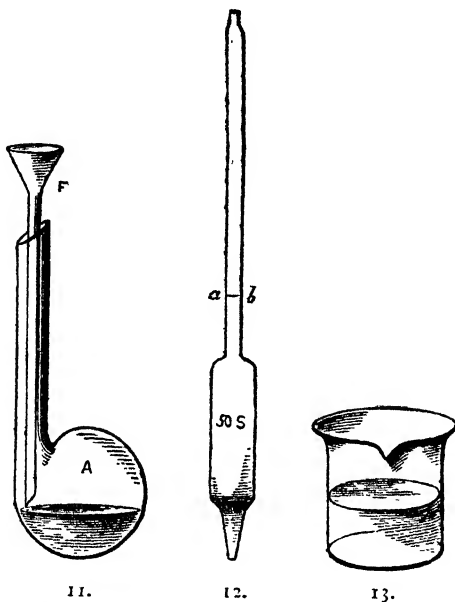


a moderate and regulated heat. The trellis *d*, placed upon the cylinder E, Fig. 7, serves to diffuse the hot air that rises from the furnace, so as to prevent its striking too violently upon any particular point of the retort.

72. PROCESS.—The apparatus, with the exception of the retort A, is to be placed together, as shown by Fig. 7. The reservoir must be filled with cold water, poured in at the funnel until it runs over at the pipe *b*. It must be ascertained that the joints at *cc* are water-tight, and that no water runs over the funnel so as to reach the bottle D.

73. Hold the retort A in the position shown by Fig. 11, and put into it the funnel F. Then, by means of the pipette, Fig. 12, which is graduated to deliver 50 septems of liquid, pass into the funnel that quantity of wine previously brought to the temperature of 60° Fahr. (See Section 176 A.) The funnel is used to avoid soiling the clean neck of the retort. To fill the pipette, the wine is put into a beaked tumbler, Fig. 13. The pipette is held in the right hand, and the wine is sucked up with the mouth until it rises higher than the mark *a b*

engraved on the neck of the pipette. The forefinger is then to be applied to the upper end of the pipette, and the wine is to be let out



in drops until the curved surface of the liquid touches the graduated line *a b*. The lower part of the pipette is then inserted into the funnel *F*, Fig. 11, and the wine is allowed to run into the retort, the last drop being blown out of the pipette by the mouth.

As accurate measurements are indispensable to success in operations of this kind, it is necessary for a beginner, or for any one who works with new instruments, to test the accuracy of the graduation upon them. The pipette to measure 50 septems of wine ought to be quite in harmony with the specific gravity bottle, which measures 100 septems. Hence, two deliveries of the pipette, made in the manner just described, should exactly fill that bottle, and the operator must study the manner of filling and delivering liquid from the pipette until he accomplishes this object with precision.

74. The wine being put into the retort, a few drops of a solution of caustic soda are to be put into it by the funnel. As much of the soda is necessary as will cause the wine to change its colour entirely. The yellow wines sometimes become brown, sometimes assume a neutral tint; the red wines assume various colours between slate grey

and dark purple. The colouring matter of red wine appears to be blue when isolated. In wines it is reddened by the free acid that is always present. When soda is added to neutralize the acid, the colouring matter resumes its blue colour; but as it is then mixed with variable quantities of brown liquor, produced by the action of alkali on the neutral organic bodies that are present in the wine, the blue tint is never clear. It is expedient for a beginner to practise beforehand this experiment of treating the wines with soda, in order that he may know the exact effect that it is necessary to observe in the retort. For this purpose, a little wine is to be placed in a glass, and drops of solution of caustic soda are to be gradually added, and stirred up with the wine by means of a glass-stirrer, until the change of colour takes place. If drops of the wine are applied by the point of a glass-stirrer to a slip of blue litmus test paper *before* the soda is added, the blue colour turns red, in consequence of the presence of free acid in the wine. If the reddened litmus paper is touched by the wine *after* the soda is added, the red colour becomes blue, in consequence of the presence of free alkali in the wine. The change of colour which takes place in the wine when the soda is added is a consequence of the neutralization of its free acid and of the subsequent action of free alkali on the colouring matter of the wine.

75. The next step is to put into the retort, by the funnel, 50 septems of distilled water, which may, like the wine, be measured by the pipette, Fig. 12, although strict accuracy is not essential in this case. After the water is inserted, the funnel is to be removed, and this must be done without soiling the neck of the retort. The funnel having been drained by applying its point against the side of the retort, the retort is to be held in the position shown by Fig. 14, and the funnel is

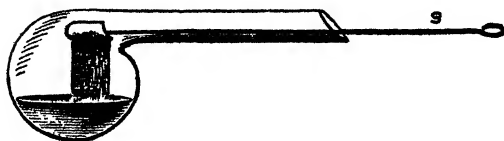


14.

to be withdrawn with a steady hand, without permitting its wet end to touch the inside of the neck of the retort.

76. Finally, it is necessary to add *one grain* of tannic acid (tannin) in fine powder to the mixture in the retort. This is to be done in the manner that is represented by Fig. 15. This figure represents the retort held with the neck in a horizontal position. The spoon S consists of a stout wire, with a cup at the end of it. The one grain of powder is put into the cup, which must be clean and dry, the spoon

is pushed into the retort so as not to touch its neck, and when the spoon is in the body of the retort, the wire is turned half-way round,



15.

upon which the powder falls into the liquor. The spoon is then carefully withdrawn without permitting it to touch the neck of the retort. I have said that *one grain* of tannin is the quantity to be used. There is no precise weight necessary for the stated purpose; but I find that this weight answers the purpose completely when 50 septems of wine are used, and the term *one grain* gives a clearer idea of what is meant than if I were to say "a little," "a pinch," or "a penknife-pointful." If the operator will for once weigh off one grain of tannin and notice how it looks in the spoon that is pictured in Fig. 15, he may subsequently take the necessary quantity by *sight* and not by *weight*. But if he prefers it, he can easily weigh off the prescribed one grain.

77. The retort is now fully charged. We have in it 50 septems of wine; 50 septems of water; as much soda as rather more than neutralizes the acid of the wine, and, finally, one grain of tannic acid. The retort is now to be inserted in the condenser, as exhibited by Fig. 7, and the joint between the retort and the condensing tube is to be closed by a caoutchouc tube, which should be carefully selected and adjusted, so as to secure a perfectly-tight joint, from which no escape of alcohol in vapour can take place during the distillation.

78. Before proceeding further with the details of the process, I may state the reasons for making such a mixture as that which we have prepared in our retort. It is necessary to give this explanation, because, in most books that have been written on this subject, the operator is desired to put the wine into the retort, and to distil it without any admixture whatever. According to my experiments, distillations of wine, made in that simple and direct way, give, in many cases, erroneous results, and the mixture which I have described is made with the intention of removing the causes of certain errors.

79. I dilute the wine with an equal volume of water, because I can then with certainty distil off the whole of the alcohol from it without heating to dryness and burning those constituents of the wine that are not volatile, but which, when burnt, produce volatile compounds that pass over into the alcohol and affect its weight. I neutralize the free acids of the wine with soda, because I find that otherwise those free

acids that are volatile distil over with the alcohol and vitiate the result of the operation. I have never found a wine from which alcohol could be distilled without an accompaniment of volatile acid. I add tannin to the mixture, because the wines that are neutralized with soda sometimes intumescence when heated, and produce great glutinous bubbles which are apt to drive some of the liquid of the retort over into the receiver; an effect which it is indispensable to prevent, and which is entirely prevented by the tannin. This use of tannin in the distillation of wines was first recommended by Dr. F. Mohr of Coblenz, to whom chemists are indebted for so many useful processes in Volumetric Testing.

80. I return to the description of the process of distillation. The apparatus is arranged as it is represented by Fig. 7. The retort A, charged with the mixture, should be rather less than half full. The reservoir C should be quite full of cold water. The tube B and the bottle D should be perfectly clean and cold. The gas-burner or spirit lamp placed in the furnace E is now to be lighted, and the flame is to be kept very low. The liquid in A is to be heated gradually until it *gently simmers*. It must never be permitted to boil strongly. After a time, liquid will appear in the bottle D. The end of the tube B must go well into the neck of the bottle D, but not close it completely, otherwise the air within the bottle will not escape properly as the liquor comes into it, but will drive some of the liquor from the tube B outside the bottle, and so spoil the analysis. By due attention to the heat disengaged by the furnace, the liquor in the retort may be constantly kept at a gentle simmering heat, at which the distillation goes on best. If the heat is too strong, the liquor may boil over and spoil the experiment. If it is too weak, the liquor may be raised into vapour too feebly, and may be condensed in the upper part of the retort, and then run downwards in cooled streams and crack the glass. The bottle D and the tube B, at the bent part, should never feel warm to the fingers. To prevent this, when the distillation has proceeded so far that the bottle D appears to be nearly one half full, about a pint of cold water should be poured into the funnel of the reservoir, Fig. 7, and warm water from the reservoir be received in a jug or beaker glass placed below the spout b for that purpose. These directions are given under the supposition that the experiment is being made in a room the atmosphere of which is at the temperature of about 60° Fahr., and where the water at command is at a few degrees below 60° Fahr. Under such circumstances, the distillation can be so made that the product received in the bottle D is within a few degrees of the 60° Fahr. at which it is necessary to weigh it.

81. The specific gravity bottle D, Fig. 7, in which the distillate is collected, contains 100 septems, or a centigallon, when filled to the mark on its neck (see § 7, page 16); but the distillation is to be stopped when

75 septems of spirit have been distilled into it. That is more than sufficient to carry over from the retort the whole of the alcohol that is contained in the wine, but I prefer this quantity rather than a smaller quantity, because the water that rises alone towards the latter part of the operation not only washes all the alcohol out of the tube B into the bottle, but leaves the tube perfectly clean for the next process. In order that the operator may know the height to which 75 septems of liquor rises in the bottle D, he should previously pass into that bottle 50 septems of water by the 50 septems pipette, and 25 septems by the 25 septems pipette, and observe the level in the bottle. It is, however, not essential in the distillation of alcohol from wine that *precisely* 75 septems should be distilled over, because 5 septems more or less than 75 consist only of water, which has no influence on the result of the operation. After two or three distillations, the operator will readily hit upon the bulk of 75 septems near enough to answer the object in view.

82. The distillation being ended, the globular part of the bottle D is to be *nearly* filled with pure distilled water at 60° Fahr., and the temperature of the mixture is to be taken by the thermometer. If it is found to be at 60° Fahr., it may be at once carefully filled up to the mark on the neck and be stoppered ready for weighing. If the temperature is above 60° Fahr., the bottle may be dipped into cold water and exposed to the air to cool it. If it is under 60° Fahr., it may be heated by the hands or by warm water till it is at 60° Fahr. The quantity of liquid being small, and the temperature, by a proper use of the condensing water, being brought nearly to 60°, the exact adjustment to that temperature is by no means difficult. When the liquid is brought to 60° Fahr., the bottle is to be stoppered and weighed.

83. I have in a preceding section (see page 15) so fully described everything that relates to the weighing of the specific gravity bottle, that nothing more remains to be said on that subject. By following the directions there laid down, you determine what is the weight of 100 septems of diluted alcohol procured by distilling 50 septems of wine. Of course, this diluted alcohol is, volume for volume, of just half the alcoholic strength of the undiluted wine.

CALCULATIONS.

84. When you have determined the weight of the 100 septems of diluted alcohol, prepared from the 50 septems of wine, the calculations which follow depend upon the manner in which you wish the ascertained quantity of alcohol to be stated. In Tables I. and II. I have shown the different forms under which the fact may be registered, and in the account given of the Alcohol Tables, I have explained the various

methods of calculation by which any desired statement may be accurately prepared. I will now point out how such numbers as those contained in the alcohol columns of Tables I. and II. are determined.

85. GRAINS OF ABSOLUTE ALCOHOL IN 100 SEPTEMS. See page 6, Table I., column 5.

These numbers are found by means of Table III., in column 3 of which the weighings of the centigallon specific gravity bottle are quoted, and on referring to column 4 of that Table you have the corresponding weight in grains of the absolute alcohol contained in the same measure. This number must be doubled to give the weight in grains of the absolute alcohol contained in 100 septems of the wine, because the quantity submitted to analysis was only 50 septems. By this method, the numbers which appear in Table I., column 5, were determined.

When the weight of the distilled spirit in the centigallon bottle is not to be found in column 3 of Table III., the corresponding number of column 4 must be calculated by the method explained under the head of *interpolation* at § 23, page 27.

86. The following TABLE (VIII.) shows the actual weight of the 100 septems of dilute spirits obtained from the wines Nos. 1 to 45 in Table I., by distilling 50 septems of the wine with 50 septems of water, collecting 75 septems of distillate, and diluting to 100 septems, as described above.

TABLE VIII.—WEIGHT in Grains of the DISTILLATE produced by Distilling 50 Septems of the WINES, Nos. 1 to 45 in Table I., and Diluting with Water to the Volume of 100 Septems.

No.	Weight.	No.	Weight.	No.	Weight.
1	688.60	16	695.51	31	694.05
2	689.88	17	693.40	32	692.69
3	688.69	18	694.10	33	691.11
4	690.41	19	693.42	34	693.70
5	690.36	20	692.30	35	694.82
6	689.90	21	694.61	36	693.42
7	691.13	22	692.79	37	695.59
8	690.60	23	693.42	38	695.38
9	688.60	24	693.46	39	693.91
10	689.84	25	693.72	40	695.80
11	690.90	26	693.93	41	692.02
12	691.04	27	693.63	42	678.03
13	691.81	28	694.75	43	679.70
14	692.23	29	694.61	44	680.12
15	693.53	30	694.46	45	683.90

87. If you desire to know the corresponding weight in grains of proof-spirit contained in 100 septems of the wine, you find it in column 5 of Table III., while column 6 gives you the per-centage of proof-spirit according to Sikes; but, in both cases, only after these numbers have been *doubled*, to compensate for the dilution of the spirit that was distilled from the wine.

88. PER-CENTAGES OF ALCOHOL, as shown in page 10, Table II., columns 3, 4, 5.

The Alcohol Tables III. to VII. relate only to mixtures of alcohol and water, not to wine. Hence it is necessary, in stating the per-centage of alcohol in a wine by *weight*, to do so in reference to the observed weight of the wine, and not in reference to that of mixtures of water and spirit. I will show the way to do so by an example drawn from Tables I. and II.

89. *Per-centage of Absolute Alcohol by Weight in Wine.*

The Old Bottled Port Wine, No. 1 in the List, weighed 699.26 grains per centigallon, and it contained in that measure 141.86 grains of absolute alcohol. We then make this calculation:—

$$699.26 : 141.86 = 100 : x.$$

$$x = 20.29.$$

That is to say, 100 grains of that wine by weight contain 20.29 grains of absolute alcohol, or the alcohol in that wine is 20.29 *per cent.* by weight.

In this manner the numbers given in Table II., column 3, were calculated.

90. *Per-centage of Absolute Alcohol by Volume in Wine.*

The per-centage by *Weight* being found in the process just described, the per-centage by *Volume* is to be found by either of the calculations explained at § 52 and § 53. Thus, taking the same example, we have:—

<p>FIRST METHOD, § 52.</p> $\frac{.9989 \times 20.29}{.7938} = 25.53$		<p>SECOND METHOD, § 53.</p> $\frac{699.26 \times 20.29}{555.66} = 25.53$
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Namely, the per-centage of alcohol by volume is 25.53.

THIRD METHOD, § 57 a:—Fully explained there.

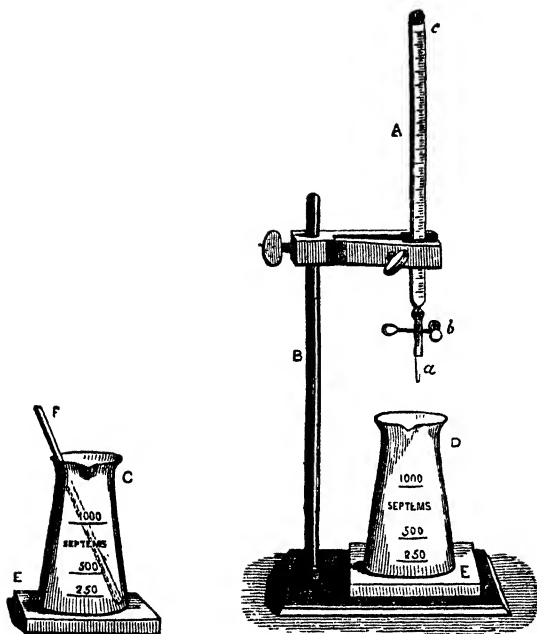
90 a. FOURTH METHOD.—The weight of the centigallon of diluted alcohol produced by the distillation of 50 septems of the Port Wine, No. 1 in Table I., was 688.60 grains. See Table VIII. Looking for this number in column 2 of Table V., p. 33, it is found to occur between the two numbers representing 12 and 13 per cent. of alcohol by volume. By Interpolation (see § 23), the true number is found to be 12.52, and doubling this, to compensate for the dilution of the alcohol, we have 25.04, which is pretty near to the former number, although

in this case we depend upon Tralles's numbers, and in the former case upon Drinkwater's.

91. *Per-centage of Proof-Spirit in Degrees of Sikes.*

When the per-centage of absolute alcohol by volume is found, you have only to multiply that number by 1.7525 to obtain the per-centage according to Sikes. (See paragraphs 60 and 38.)

If you desire to express the per-centage of alcohol according to Sikes in Excise phraseology, namely, as *over-proof* or *under-proof*, you can do so on the principles explained in § 30—32, at p. 28. *



16.

EXPERIMENTAL DETERMINATION OF THE QUANTITY OF FREE ACID IN WINES.

101. In order to be enabled to register the results of experiments made on the ACIDITY OF WINES, it is necessary to have a STANDARD with which different degrees of acidity can be compared. Such a standard may consist of a solution containing 500 grains of pure crystallised tartaric acid dissolved in a gallon of water. For convenience in reckoning, the gallon may be considered as divisible decimally, as already explained at § 8, page 16; namely, the gallon into 10 decigallons, the decigallon into 10 centigallons, the centigallons into 100 septems; according to which method of dividing the gallon—

5	gallon =	10000 septems	will contain	500	grains	} of the crystallised tartaric acid.
$\frac{1}{10}$	gallon =	1000 septems	"	50	grains	
$\frac{1}{100}$	gallon =	100 septems	"	5	grains	
$\frac{1}{1000}$	gallon =	10 septems	"	$\frac{1}{2}$	grain	
$\frac{1}{10000}$	gallon =	1 septem	"	$\frac{1}{200}$	grain	

102. With this standard tartaric acid, I propose to compare the acidity of all wines whatever, and to state the observed acidity of any wine in terms depending upon this standard, that is to say, to state that the wine contains 300, 400, 500, or other number of grains of acid in a gallon, as may be found by the experimental test.

On referring to page 6, Table I., column 6, examples will be found of the expression of the acidity of many wines on this plan, and these numbers deserve particular attention as a whole. Setting aside the acidity of the decomposed wine, No. 23, it will be seen that the acidity of the entire series of wines ranges between the two extremes of 250 grains and 500 grains of acid in the gallon, and looking at the characters of the wines that are enumerated in the Table, we are in a position to draw the following conclusions:—

1. Good wines contain a quantity of acid that is equivalent to from 300 to 450 grains of crystallised tartaric acid in a gallon.
2. Wines with less than 300 grains of acid in a gallon are too flat to be drinkable with pleasure.
3. Wines with more than 500 grains of acid in a gallon are too sour to be drinkable with pleasure.

103. These general conclusions are modified in special instances, as far as regards the pleasant drinkableness of the wines, by the effect of the different proportions of alcohol, sugar, extractive matter, and volatile flavouring ingredients that co-exist with the acid in the wines. Thus, the deficiency of acids in ports and sherries, in which the acid is often as low as 250, is compensated by the presence of an enormous quantity of alcohol and sugar. Without that compensation the wines would be intolerable. Thus, if *Vin ordinaire*, No. 37 in the List, which contains 500 grains of acid, and 4856 grains of alcohol in the gallon, were to be reduced to 250 grains of acid, and correspondingly to 2428 grains of alcohol, it would be very poor stuff indeed; for the port wine contains, with 250 grains of acid, not less than 14,000 grains of alcohol, or is six times stronger than the *Vin ordinaire*. To the entire class of light wines it will be found that these three conclusions apply precisely, both as respects the range of acidity and the method adopted for its definition.

APPARATUS AND TEST LIQUORS REQUIRED FOR ESTIMATING ACIDITY IN WINES.

A. APPARATUS.

104. The chief instruments are represented in Fig. 16, page 61. They are as follows:—

Mohr's Burette, Fig. A, which consists of a long glass tube open at both ends, graduated from top to bottom with a scale showing septems and $\frac{1}{3}$ ths of septems; *a* is a narrow glass tube with a very

small orifice for delivering a slender stream or even single drops of liquor. It is joined to the tube A by a tube of vulcanised caoutchouc that fits tight to both tubes, and across this caoutchouc tube is placed a metal pinchcock *b*, which closes the passage when it is untouched, but which can be opened by pressing the knobs *b* with the thumb and finger, so as to allow any desired quantity of liquor to pass from the burette A into the jar D. *c* represents a stone marble to be put on the top of the burette when it is not in action, to prevent evaporation of the liquor and the falling of dust into it. B represents a support for the burette A, by which it can be fixed at any desired height above the jar D. C and D represent two thin glass jars of the same size, with three marks indicating the bulk of 250, 500, and 1000 septems of liquor. E E represent two slabs of white glazed china, which are put below the jars, to render visible any changes of colour that may be produced by the chemical alterations that are made to take place in the mixtures contained in the jars C, D. F is a glass rod for stirring the liquors that are contained in the jars.

Besides these instruments there are required a bulb pipette to measure 10 septems, Fig. 17; another similar pipette to measure 25 septems; a small narrow ungraduated pipette; and some litmus test paper in small books.



B. TEST LIQUORS.

105. STANDARD TARTARIC ACID is prepared by dissolving pure crystallised tartaric acid in distilled water, in such proportions that every 100 septems of the solution shall contain 5 grains of the crystallised acid. (See the Table in § 101, page 61.) It is necessary to prepare a small quantity of this standard acid in order that the operator may satisfy himself of the correctness—the *certainty*—of the standard, according to which the acidity of wines is proposed to be estimated; but it is not advisable to prepare a large quantity of this solution, because it soon turns mouldy and becomes useless. Some other test acid can be used instead of tartaric acid, dissolved in quantities that represent chemical equivalents, such as the following:—

	1 Atom.	$\frac{1}{2}$ Atom.
Crystallised tartaric acid $\text{H}_2\text{C}^2\text{H}^2\text{O}^8$	75°	50°
Crystallised oxalic acid $\text{H}_2\text{CO}^2 + \text{H}^2\text{O}$	63°	42°
Hydrated acetic acid $\text{H}_2\text{C}^2\text{H}^3\text{O}^3$	60°	40°
Hydrated nitric acid H_2NO^3	63°	42°

According to this table, a standard acid, perfectly equivalent to that prepared with 500 grains of tartaric acid in the gallon, may be made with 420 grains of crystallised oxalic acid, 400 grains of hydrated acetic

acid, or 420 grains of hydrated nitric acid. The tartaric and oxalic acids can be directly prepared by weighing out and dissolving the crystals in water and diluting the solution to the proper bulk in a bottle with a mark on the neck indicating 100, 500, or 1000 septems. The other acids must be prepared by dilution after testing their strength against the ammonia test. The acid which I prefer for all the operations in wine testing that demand a test acid is nitric acid. All these test liquors can be purchased in London ready for use; but as they may happen to be required in remote districts (such as vineyards in the colonies), I shall describe the method of making them. This will have the disadvantage of making the operation appear tedious; for the liquors must be accurately made, and it is more troublesome to make them than it is to use them.

106. PREPARATION OF STANDARD ACID.—Weigh out 25 grains of crystallised tartaric acid, or 21 grains of crystallised oxalic acid, and put it into a flask having the form of Fig. 18, and a mark on the neck that indicates the bulk of 500 septems. Fill the flask half full of distilled water, warmed a little to dissolve the acid. Dilute with water *nearly* to the mark on the neck. Let the mixture cool till the temperature of it is 62° F., and then carefully drop in water with a pipette, till the mark on the neck is exactly reached. Shake the mixture well, and the standard acid is prepared. Every septem of this liquor is equal to .05 grain of crystallised tartaric acid.



107. PREPARATION OF STANDARD AMMONIA.—The test liquor to be used in examining the acidity of wines is a solution of caustic ammonia, of such strength that 1 septem of it will exactly neutralize 1 septem of the standard acid, and will therefore indicate .05 grain of acid. Its chemical strength, like that of the standard acid, is $\frac{2}{3}$ atom, and as the atomic weight of ammonia NH_3 is 17, the quantity of it that corresponds to 50 grains of tartaric acid is $11\frac{1}{3}$ grains. This is only the $\frac{1}{188}$ th part of the strength of ammonia saturated at 62° Fahr., and $\frac{1}{80}$ th part of the strength of ammonia of specific gravity .960, which is an ordinary commercial strength. In this condition of great dilution, the standard ammonia can be kept in a cool place for a long time with very little change in strength. The ammonia to be used for preparing the standard liquor must be quite pure and prepared with distilled water. It can be diluted to the strength proper for wine testing as follows:—

108. Set up the apparatus as represented in Fig. 16, and see that the jar D is perfectly clean, and the burette A both clean and dry. The burette can be easily cleaned within by a tube brush, having a sufficiently long handle. Put into the jar D 50 septems of the standard

acid, 105, measured by the pipette, Fig. 12, in the most careful manner possible. As this is a fundamental experiment, the difference of a *drop* of liquor is important. Also measure 50 septems of the acid into the jar C. Dilute the acid in D with distilled water, till the mixture measures 250 septems, according to the mark on the jar. Add two or three drops of the red hematine colour test described at paragraph 117, and stir the mixture with a glass rod F, Fig. 16, upon which it assumes a bright lemon-yellow colour. Prepare the jar C in the same manner. Set both jars aside while the burette is made ready for the experiment that is to follow.

Into a glass beaker or flask put a quantity of strong liquid ammonia and add 30 or 40 times its bulk of distilled water; shake the mixture, and fill the burette A, Fig. 16, with it. To do that properly, a little of the mixture should be put into a small beaked tumbler, Fig. 13, page 53; the jet *a* of the burette should be dipped into the liquor, the pinchcock *b* being opened by pressure, and a little of the liquor should be sucked up into the burette, but only as much as suffices to appear just above the pinchcock. This is then to be closed, and the liquor is to be poured into the burette at the top till the instrument is filled to a little above the line marked 0°. The reason why a small quantity of the liquor is first to be sucked up into the lower end of the tube is that otherwise some air remains within the caoutchouc tube and becomes troublesome. I have said that the burette should be not only clean but *dry*, and I might have said the same of the pipette, Fig. 12, directed to be used to measure the test acid. As, however, dryness is sometimes difficult to effect in vessels with narrow necks, or with only one neck, it is proper in all testing operations to *wash out*, once or twice, the measure that is to be used for any purpose with some of the liquor that is to be measured in it. On this principle the burette A may be first washed out with a little of the diluted ammonia before it is filled with it for use.

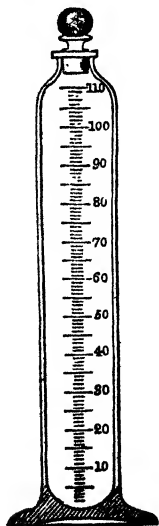
109. The burette having been filled with the ammonia a little above the mark zero, 0°, is to be adjusted. Bring under the jet *a* an empty glass, not the jar D, fix your eye upon the line 0°, at the top of the burette, and gently press the pinchcock *b*, so as to allow the liquor to run out in single drops until the surface of it in the burette coincides with the line 0°. By the surface I mean the lower part of the black curve which is seen when you look across the tube, especially if you hold a piece of thin paper behind it.

110. The burette is now ready for use. Bring back the two jars C and D, with their prepared contents, into the positions shown by Fig. 16, page 61, open the pinchcock *b*, and permit the ammonia to run down into the acid—at first in quantities of 3 or 4 drops at a time, and soon diminishing the supply to 1 drop at a time. The action of the ammonia upon the bright lemon-coloured mixture of acid and hematine is to

change the colour, first to brown, next to pink, and finally to crimson. The brown colour indicates the point of neutrality; the pink and crimson solutions are alkaline. The reaction is extremely delicate, and the change of colour very beautiful. After each addition of ammonia, the mixture should be stirred, or what is preferable, the jar should be lifted up and gently shaken with a circular motion, which speedily diffuses the alkali among the acid. When the brown colour appears, the acid is all neutralised, and you may read on the burette how many septems of the diluted ammonia have been used for that purpose. Note down the number. It will then be found that if the materials are all pure, one drop more of the ammonia will suddenly render the whole mixture pink, while a second drop will deepen its colour, and a third will render it crimson. The drops of ammonia that are added after the mixture becomes brown are in excess of the quantity required to neutralize the acid, and must be withdrawn from the reckoning. °

111. In making these experiments with colour tests, it will be found that the white china slabs E E, Fig. 16, that are placed below the glass jars, throw up the colours beautifully, and greatly assist the observation of slight changes.

112. The first experiment being ended, the test liquor in the burette A should be adjusted to the nearest whole number on the scale by letting a few drops run out to waste. The jar C is then to be brought into the position of jar D, and the testing is to be repeated with the utmost care. You now know pretty nearly, if not exactly, how many septems of the ammonia are required to neutralize the acid in the jar. To save time, all that quantity within 3 or 4 septems is to be run out at once, the mixture in the jar to be well shaken, and the rest of the alkali to be added in single drops, shaking the mixture after each addition of one drop, and stopping the process when the brown colour appears in the mixture. If all the measurements have been correctly made, the reading of the scale at this point should indicate exactly the strength of the ammonia compared with that of the standard acid.



19.

113. The 50 septems of test acid submitted to this trial should take for neutralization 50 septems of test ammonia. But the testing just described may have shown that 35 septems of the dilute ammonia sufficed for that purpose. In that case, the dilute ammonia requires, for conversion into test ammonia, a dilution of 35 measures to 50 or of 70 measures to 100. This dilution is best effected in an instrument called a *Test-Mixer*, which is represented by

Fig. 19. It may be of any capacity, but it is usually made to contain 1, 2, or 5 decigallons. It is graduated into 100 parts. When used for such an operation as the above, it is accurately filled to the mark 70 with the tested ammonia, and then distilled water is gradually added until the measure is completed to 100. After each addition of water, the stopper is put into the mixer, and the whole is well shaken, and when the addition to 100 is completed the whole is thoroughly shaken to insure a perfect mixture. This should take place at 62° Fahr. The test alkali thus prepared will be exactly equal, septem for septem, with the normal test acid, and is fit for the wine test.

114. PREPARATION OF STANDARD NITRIC ACID. — Standard nitric acid can be prepared against standard ammonia by an operation perfectly similar to that by which the ammonia is prepared against tartaric acid; namely, pure nitric acid is diluted with water and put into the burette, 50 septems of standard ammonia is put into each of the two jars C and D, hematine colour test is added to each, which instantly gives the ammonia a crimson colour, and to this mixture the nitric acid is added from the burette until the colour of the mixture becomes brown, and finally bright lemon colour. The strength of the diluted nitric acid being thus determined it is diluted to standard strength by the help of the test-mixer as already explained.

115. This standard nitric acid contains in 1 septem, as already shown at § 105, .042 grains of hydrated nitric acid, answering to the formula HNO^3 . This is equivalent to the following quantities of several acids and bases—

Ammonia . . .	NH^3	·01134
Hydrate of soda . .	NaHO	·0267
Hydrate of potash .	KHO	·03734
Carbonate of potash .	K^2CO^3	·046
Quicklime . . .	CaCaO	·01867
Carbonate of lime .	Ca^2CO^3	·0334
Tartaric acid . . .	$\text{H}_2\text{C}^2\text{H}^2\text{O}^3$	·05
Acetic acid . . .	$\text{H}_2\text{C}^2\text{H}^3\text{O}^2$	·04
Nitric acid . . .	H_2NO^3	·042
Tartrate of potash .	$\text{K}_2\text{C}^2\text{H}^2\text{O}^3$	·0754
Bitartrate of potash .	$\left\{ \begin{array}{l} \text{H}_2\text{C}^2\text{H}^2\text{O}^3 \\ \text{K}_2\text{C}^2\text{H}^2\text{O}^3 \end{array} \right\}$	·1254

116. This standard nitric acid is not liable to change, and it can be used to test, from time to time, the accuracy of the test ammonia, which is a little, but only a little, liable to change. It is also proper, occasionally, to prepare a small quantity of solution from fresh crystals of tartaric or oxalic acid, to check the ammonia, and through it, to check the nitric acid. These reactions are such as to render it needless to take for granted the accuracy of any single test liquor. To go

upon sure ground, every operator in this kind of analytical work must be at all times able to tell whether his tests speak the truth or not.

117. **HEMATINE TEST LIQUOR.**—This is best prepared by boiling in water a few chips of pale-coloured sound logwood. Rough chips of a dark colour that have been long exposed to the air are unfit for this use. The solution should be strong and have a deep orange-red colour. Unfortunately, it soon spoils, and must be frequently prepared fresh. The addition of alcohol makes it keep longer, but injures the colour. The best thing that can be done is to keep the logwood in chips or turnings in a closely-stoppered glass bottle, and to make a fresh solution when it is wanted, by boiling a few chips with water in a small flask



placed on the furnace E d, Fig. 7. The solution will keep some weeks in a closely-stoppered bottle. In the operation of testing it is applied by a small glass pipette, and it is advisable as far as possible to have the liquor of uniform strength, and always to supply the same quantity of it, so as to insure uniformity of action as nearly as the circumstances permit. The tincture may be conveniently kept in a capped bottle containing a pipette, as represented by the figure in the margin. The hematine colour test can only be used with diluted liquors. Strong acids

and alkalis destroy it.

THE PROCESS OF TESTING WINES FOR ACIDS.

118. Having now fully explained our tools and tests, we may proceed to apply them to the examination of the acidity of wines. The general outline of the process is similar to that used in the testing of ammonia, and which I have described in paragraph 108. The apparatus is arranged as it is represented in Fig. 16, page 61. The burette A is filled with test ammonia. The wine to be tested is put into the two mixing jars C and D; it is therein diluted with water, mixed with colour test, and subjected to the action of the test liquor. But wine is not pure acid, and the testing of wine does not therefore go on so smoothly and readily as the testing of solutions of pure acid. We have in wine two obstacles to contend with, which demand special attention: these are *colouring matter* and *tannin*, both present in every wine in various and unascertainable proportions. The effect of these obstacles is to confuse and deaden the action of the colour test. Instead of permitting the colour test to work as it is described above, passing from pure yellow to brown, then to pink, and finally to crimson, these components of wine cause the colour test to lose its beautifully bright yellow and pink and crimson colours, and to pass through endless shades of brown, greenish brown, and reddish brown, which puzzle the eye, and render a perception of particular shades nearly impossible. The contrivances by which these obstacles have been most effectually overcome I may

best describe in the following practical directions for the testing of wines in their presence.

119. Put into each of the mixing jars C and D (Fig. 16, page 61) 10 septems of the wine of which you wish to ascertain the acidity. If it is white wine (hock, sherry, &c.), add distilled water till the measure (marked on the mixing jar) is 250 septems. If it is red wine (port, claret, &c.), add water till the measure is 500 septems. These are the general rates of dilution; but I have found some kinds of port, such as those marked Nos. 3 and 12 in Table I., to be so charged with colouring matter (probably artificial colouring matter) that it became necessary to dilute the 10 septems of wine to 1000 septems of mixture; namely, to make a dilution of from 1 to 100; but these were rare examples.

120. The wines being diluted in the two jars, hematine colour test is to be applied to each, in quantity as nearly as possible the same. The hematine gives to the mixture a colour which closely resembles that which is produced by painting paper with the colouring material called *Raw Sienna*; and I recommend the operator to paint a piece of paper with that colour to serve as a standard of comparison.

The two mixing jars C and D, thus carefully prepared, are to be placed, one below the burette, and the other near to it, as is represented in Fig. 16, page 61; the burette A being previously filled with the test ammonia and properly adjusted to 0° for use. The test ammonia is then to be slowly dropped into the jar D, the jar being from time to time shaken with a circular motion to mix the ammonia with the wine. Gradually, very gradually, the colour of the mixture in the jar D deepens, becomes browner, more of a reddish brown; but this change takes place so gradually that if the jar C were away you would scarcely perceive the change in colour. The raw sienna colour in the jar C serves therefore as a useful standard of comparison. You continue to permit the test ammonia to flow into the diluted wine a drop at a time, with constant shaking of the mixture to diffuse the test properly, until you suddenly find the mixture to assume a peculiar reddish-brown colour, which is entirely different from the raw sienna colour still visible in the jar C; but which you can accurately imitate by painting a piece of paper with the colour which bears the name of *Burnt Sienna*. If you draw upon paper two figures of the full size of the jars C and D, used for this experiment, and paint one of these jars up to the mark 500 with raw sienna, and the other with burnt sienna, you will be provided with a gauge by which you can tell when the acid in the diluted wine is neutralized by the test ammonia.

Arrived at this point of neutralization, you can read off the number of septems of test liquor that has been demanded to produce this effect, of which number you take a note.

121. You now adjust to a whole number the liquor in the burette, change the places of the jars C and D, and proceed to neutralize the acid

of the wine in the jar C, adding at once within 2 or 3 septems of the entire quantity of test liquor required, and then adding it drop by drop till the true degree is exactly ascertained. You stop as before when the burnt sienna colour is produced, and you take a note of the quantity of test ammonia that is used for the neutralization of the acid.

122. To remove any doubt that may exist as to the perfect neutralization of the acid in the wine, you may now add ammonia drop by drop to the red-brown coloured liquid. You will find it readily to become, not pink, but full-coloured dirty red. After this colour is produced, if you let the mixture rest quietly, it soon returns to the brown colour; for the pink-coloured compound of hematine and ammonia is not permanent.

CALCULATION OF RESULTS.

123. Suppose that 10 septems of wine, whether diluted to 250 septems or to 500 septems, have required 9.1 septems of test ammonia to neutralize its acid, then 100 septems of wine would require 91 septems of the test ammonia; and as every septem of the test ammonia indicates .05 grain of tartaric acid, we have only this calculation to make:—

$$\begin{array}{rcl} 91 & \text{or,} & 9.1 \\ .05 & & \hline 4.55 & & 2 = 4.55 \end{array}$$

Namely, the wine contains 4.55 grains of acid in 100 septems, or 455 grains in a gallon.

124. Supposing the tests to be properly prepared, the accuracy of this result depends chiefly upon the precision with which 10 septems of wine can be measured out for analysis. If that measurement is right, the result is right; but any over- or under-measurement brings error into the result. The operator must therefore carefully study the method of accurate measurement with the pipette.

125. In cases where the colouring matter and the tannin are not overpowering, larger quantities of wine may be tested, and thus the error due to mismeasurement will be lessened. But large quantities, such as 25 or 50 septems, of wine cannot be tested when the colour of the wine is strong, because the great quantity of dilution water required would produce much inconvenience.

The numbers given in Table I., column 6, as representing the total acidity of certain wines, were determined by the above-described process.

ATTEMPTED SEPARATION OF THE VOLATILE FROM THE NON-VOLATILE ACIDS OF WINE.

126. In the preceding section, I have taken tartaric acid as the standard to which the acidity of wines is to be compared. No other acid seems to me to be so well suited for that standard, or so well entitled to be placed in that position. Although malic acid is present,

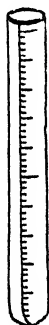
tartaric acid is, without doubt, the most important non-volatile acid in wines, both in constancy and in quantity.

But wines contain volatile acids in addition to non-volatile acids, and the chief of these volatile acids is the acetic acid. Of the wines that are enumerated in Table I. not one was found to be free from volatile acid, which, from such trials as were made, always appeared to be principally acetic acid.

An attempt was made to *separate* the volatile from the non-volatile acids of these wines, with a view to determine their respective quantities. The attempt was not entirely successful; but I will nevertheless describe how it was made and how far it proved satisfactory.

127. I set up the apparatus for distillation just as it is represented in Fig. 7, page 51, excepting that, instead of the bottle D, I used as a receiver a glass tube of the form of Fig. 20, about 6 inches long and $\frac{5}{8}$ inch in diameter. This was graduated into 50 septems, or a little more.

Into the retort A, I put 50 septems of the wine that was to be tested, and 50 septems of water, but no soda. If the wine was of the sweet kind I added a dose of tannin in the manner described at page 55; but if it was not sweet, I omitted the tannin. If I happened to have no retort of the wide form represented by A, Fig. 7, but had to use a narrow pear-shaped retort, then also I used tannin, in order to prevent the boiling over of large bubbles. The mixture being prepared, I submitted it to slow distillation, and collected the distilled acid in the graduated tube. When 50 septems were distilled over I changed the tube receiver for another graduated in a similar manner, in which I collected 30 septems. By that time some of the wines that were rich in sugar became too thick to permit of farther distillation without risk of burning their solid matter or breaking the retort. In that case, the distillation was stopped; but when there was evidently but little sugar or other fixed residue in the wine, so that the 20 septems of mixture still remaining in that retort appeared to be in a thin liquid condition, the distillation was continued at a very low temperature, and 17, 18, or 19 septems was collected in the graduated tube that was first used, the 50 septems of distilled acid first collected having meanwhile been washed into a mixing jar. By this arrangement, the distilled acid was collected in three portions, measuring 50 septems, 30 septems, and 17 to 20 septems.



20.

CALCULATION OF THE ACID CONTAINED IN THE SEVERAL PORTIONS OF DISTILLATE.

As 50 septems of wine are used, the number of septems of test ammonia used to saturate the acid has only to be divided by 10, that is to say, to have the decimal point of the figures removed one place to

the left hand, to show the true weight of the acid indicated. Thus, if 50 septems of the distilled acid take 2.4 septems of test ammonia, the quantity of acid indicated is .24 grain; for, if 50 septems of wine take 2.4 septems of the test ammonia, 100 septems would take 4.8, and since every septem of test ammonia is equal to .05 grain of acid, that figure by multiplication with 4.8 produces .24; thus:—

$$\begin{array}{r} 4.8 \\ .05 \\ \hline .240 \end{array}$$

RESULTS OF THE TESTING OF THE DISTILLED ACIDS.

128. In column 7 of Table I., page 7, I have given an account of the quantity of acid found in the first 80 septems that were distilled from each wine. This is the reason that I have headed the column "VOLATILE ACIDS AT $\frac{80}{100}$." For the sake of preserving comparative uniformity in the calculations, this distilled acid is, like the fixed acid, reckoned as being tartaric, though unquestionably it is not tartaric. If reckoned as acetic acid, the weight of it would be $\frac{1}{4}$ th part less. But since the same acid, taken in company with the fixed acids, is reckoned in column 6 as tartaric acid, it is reckoned so also in column 7, in order to bring out, by way of difference, the true quantity of the fixed acids as expressed in column 8.

129. But it was quite evident, on a close examination, that the distilling of the wines till some of them became dry, that is to say, to the point of $\frac{80}{100}$, did not drive off the whole of the volatile acids; evidence of which is given in the following Table (IX.), in which I have given the amount of acid, still reckoned as tartaric acid, first as contained in the 50 septems, then in the 30 septems, and finally in the 17, 18, or 19 septems, which finished the distillation. The Visanto wine, No. 16, and the Cyprus, No. 17, became too dry at $\frac{80}{100}$ to suffer farther distillation. The other wines yielded in all from 97 to 99 septems of distillate.

130. An examination of this Table shows that, in nearly all cases, the acid given off in the last 20 septems was greater in amount than that distilled off in the first 50 septems; while there is no evidence to prove that, even when the distillation closed and the wine became dry, all the volatile acid had been separated from the residual extract.

131. I conclude, therefore, that it is not in our power, at any rate by this process, completely to separate the volatile acids of wine from the non-volatile. We can do it to a certain extent, but not thoroughly. We can do it on an arbitrary footing, such as that of $\frac{80}{100}$, which I have adopted, and we must make what good use we can of that limited amount of analytical power until chemists help us to a more effectual process.

A comparison of the numbers given in columns 7 and 8 of Table I.,

TABLE IX.—FRACTIONAL DISTILLATION of VOLATILE ACIDS from WINES.

1	2	3	4	5	6	7	8
No.	Names of the Wines.	First Fraction 50 Sep- tems.	Second Fraction 30 Sep- tems.	Third Fraction 25 Sep- tems.	Total Volatile Acids.	Total Free Acids.	Fixed Acids.
1	Old-bottled Port . . .	.22	.22	.28	.72	2.50	1.78
2	Newly-bottled Port . . .	.20	.24	.28	.72	2.65	1.93
5	Montilla, 1854 . . .	.32	.44	.44	1.20	3.00	1.80
6	Ditto, newly bottled . . .	.34	.34	.36	1.04	3.00	1.96
7	Oloroso, 1843 . . .	.24	.24	.28	.76	2.80	2.04
8	Ditto, newly bottled . . .	.24	.24	.28	.76	2.80	2.04
15	Lachryma Christi . . .	.40	.40	.62	1.42	4.30	2.88
16	Visanto . . .	.42	.52	.00	.94	4.60	3.66
17	Cyprus . . .	.44	.48	.00	.92	4.70	3.78
18	Santorin . . .	.19	.21	.21	.61	4.45	3.84
19	St. Elie . . .	.20	.18	.16	.54	4.55	4.01
21	Red Keflesia . . .	.41	.39	.44	1.24	3.70	2.46
24	Red Mont Hymet . . .	.82	.76	.80	2.38	4.95	2.57
25	Ditto . . .	.60	.54	.60	1.74	3.70	1.96
26	White Mont Hymet . . .	.29	.30	.38	.97	3.20	2.23
28	St. Georger . . .	.36	.21	.62	1.19	4.60	3.41
30	Erlaure . . .	.28	.24	.28	.80	3.60	2.80
32	Dioszegez Bakator . . .	.22	.26	.31	.79	4.25	3.46
39	St. Julien, 1858 . . .	.52	.43	.76	1.71	4.50	2.79
19	Wines. AVERAGE . . .	.35	.35	.37	1.07	3.78	2.71
23	The fractional distillation of the putrid Wine No. 23 in Table I. produced these results	3.53	3.32	2.53	9.38	13.00	3.62
1	2	3	4	5	6	7	8

and of those in columns 6 and 8 of Table IX., shows that the Fixed Acids occur in quantities that are much more uniform than the quantities of the Volatile Acids. The fixed acids cannot reach beyond a certain point, in consequence of their insolubility in alcohol. As the latter increases in quantity, the former diminishes. And there is nothing to cause increase in the quantity of fixed acids. But acetic acid can exist to any extent in the presence of alcohol; and its quantity in wine may increase continuously, at a rate commensurate with the carelessness with which the wine is treated.

132. As physicians commonly refer to the acidity of wines, as possessing a certain number of grains of tartaric acid either in a fluid ounce or in a pint of wine, I add the following Table (X.) to facilitate computations.

TABLE X.—ACIDITY of WINES, estimated as GRAINS of TARTARIC ACID in FLUID OUNCES of WINE.

Grains in a Fluid Ounce.	Grains in a Pint.	Grains in a Gallon.	Grains in a Fluid Ounce.	Grains in a Pint.	Grains in a Gallon.
1	20	160	$2\frac{1}{8}$	$42\frac{1}{2}$	340
$1\frac{1}{8}$	$22\frac{1}{2}$	180	$2\frac{1}{4}$	45	360
$1\frac{1}{4}$	25	200	$2\frac{3}{8}$	$47\frac{1}{2}$	380
$1\frac{3}{8}$	$27\frac{1}{2}$	220	$2\frac{1}{2}$	50	400
$1\frac{1}{2}$	30	240	$2\frac{5}{8}$	$52\frac{1}{2}$	420
$1\frac{5}{8}$	$32\frac{1}{2}$	260	$2\frac{3}{4}$	55	440
$1\frac{3}{4}$	35	280	$2\frac{7}{8}$	$57\frac{1}{2}$	460
$1\frac{7}{8}$	$37\frac{1}{2}$	300	3	60	480
2	40	320	$3\frac{1}{8}$	$62\frac{1}{2}$	500

To show the incorrect notions respecting the acidity of wines which at present pass current with the public, I copy the following note from a letter in the *Morning Star* of December 1, 1865.

"In order that your readers may know how much nutriment to expect from the cheap wines, I give below an analysis taken from the food department of the South Kensington Museum, of four different wines, which I suppose are of the 'best descriptions':—

ANALYSIS.

	Pint of	Water.	Alcohol.	Sugar.		Tartaric Acid.
		Oz.	Oz.	Oz.	Gr.	Gr.
Claret	. . .	18	2	..		161
Port	. . .	16	4	1	2	80
Champagne	. . .	17	3	1	133	90
Sherry	. . .	$15\frac{1}{2}$	$4\frac{1}{2}$	0	360	90

"Trusting that, with your usual kindness, you will insert this letter, I beg to remain, Sir, your obedient servant,
N. M. G."

According to "Nemo," claret contains 161 grains of tartaric acid in a pint. No. 37 of column 6 of Table I. compared with 500 grains in Table X. shows that the sourest *Vin ordinaire* contains $62\frac{1}{2}$ grains of acid in a pint. Port, which Nemo states at 80 grains, really contains (see Nos. 1 to 3 in Table I.) from 31 to 34 grains in a pint. Champagne, instead of 90 grains, according to my trial (No. 35, Table I.) contained 47 grains; and sherry, instead of containing 90 grains, varied (see Nos. 5 to 10, Table I.) from 35 to 45 grains per pint. The idea that any claret contains 161 grains of tartaric acid in a pint is preposterous. Such a degree of acidity would amount to about 2 per cent. of the wine, while the sourest wine that man can drink without a

shudder does not contain 1 per cent. of acid. (See column 6 of Table II.)

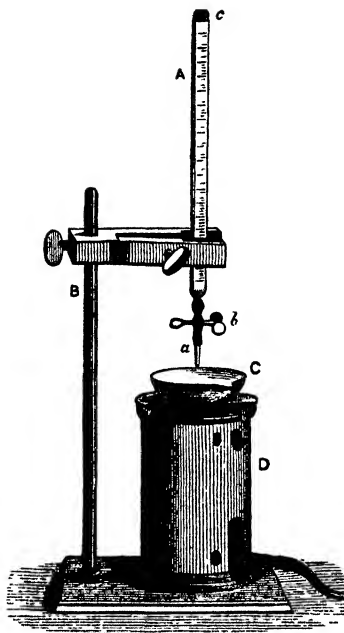
SPECIAL EXAMINATION OF THE ACIDS IN THE PUTRID WINE No. 23,
KEFFESIA, CONTAINING FLIES. DETECTION OF FORMIC ACID.

133. This wine was corked up with a few small flies in it. At the end of a year it was examined. The results of the testings are given in Tables I, II, and IX. But in consequence of its containing so large a quantity of free acids, their nature was examined.

The undistilled wine contained traces of hydrosulphuric acid, carbonic acid, tannic acid, and silicic acid; a considerable quantity of tartaric acid and of phosphates. It was free from malic, citric, and succinic acid.

The acid separated so abundantly by distillation seemed entirely to consist of acetic acid and formic acid. The reactions with tests were as follow: Ferric chloride changed the colour of the acid to deep red, but gave no precipitate. Boiled with alcohol and sulphuric acid, it gave off acetic ether. With mercurous nitrate, it gave a whitish precipitate, which became grey when boiled. When mercurous nitrate was added till the precipitate ceased to form, and the precipitate was separated by filtration, and the filtered liquor boiled with more mercurous nitrate, metallic mercury appeared. When red oxide of mercury was heated with the acid and then cooled, an abundant crop of crystals of formiate of mercury was formed. When these crystals were removed, and the residue of red oxide of mercury was boiled a long time with more of the solution, the mixture produced a considerable quantity of metallic mercury.

I have not found formic acid in any other wine.



EXPERIMENTAL DETERMINATION OF THE QUANTITY OF SUGAR IN WINES.

136. Among the numerous varieties of sugar that are known to chemists, there are two that have a particular interest in connection with the study of the composition of wines. These two sugars are called *Cane Sugar* and *Grape Sugar*. They have other names than these two, but we need not in this place perplex ourselves with synonymes. Both of these kinds of sugar are composed of carbon, hydrogen, and oxygen, but in different proportions; and it is therefore necessary for us to understand what relation these proportions bear to one another. We shall attain our end easily, by employing chemical symbols to state the proportions of the elements which compose these sugars. I use, then, the letter C to signify 12 parts by weight of carbon, H to signify 1 part by weight of hydrogen, and O to signify 16 parts by weight of oxygen.

137. The formula CH^2O indicates in the simplest possible form the composition of *Grape Sugar*, pure and uncombined with water; and taking the weights as given above, it signifies 30 parts by weight of grape sugar, or, as it is sometimes called, *Anhydrous Grape Sugar*. It is in this condition that it is assumed to exist in wines, and when we talk of testing for sugar in wines, we mean to test for this compound, CH^2O .

138. But when grape sugar is brought into the dried state, it forms *crusts* or *crystalline masses*, which are quite dry, but which contain water, and form a compound the composition of which is indicated by the following formula:— $6 \text{CH}^2\text{O} + \text{HHO}$. This means, that six atoms of CH^2O or sugar are combined with one atom of HHO or water, the whole possessing this weight:—

$$\begin{array}{rcl} 6 \text{ times } \text{CH}^2\text{O} \text{ at } 30 \text{ each} & = & 180 \\ 1 \quad \quad \quad \text{HHO} \quad \quad 18 & = & 18 \end{array}$$

$$\text{Together} = 198$$

139. Now, cane sugar, such as crystallised sugar candy, or loaf sugar, has a much more complex composition, which I may represent thus:— $11 \text{CH}^2\text{O} + \text{C}$. Namely, it contains 11 atoms of the simple form of sugar CH^2O and 1 extra atom of carbon. The weight will therefore be as follows:—

$$\begin{array}{rcl} 11 \text{ times } \text{CH}^2\text{O} \text{ at } 30 \text{ each} & = & 330 \\ 1 \quad \quad \quad \text{C} \quad \quad \text{at } 12 & = & 12 \end{array}$$

$$\text{Together} = 342$$

When I come to speak of the composition of “Must,” these figures will come fully under consideration. In this section I merely want to establish the separate identity of the two sugars.

140. The Testing for Sugar in Wines takes place in this manner: A measured solution of a salt of copper, which I shall describe presently, and which is a beautiful clear blue liquid, is heated in a white porcelain basin, and the wine to be tested, being deprived of its colour and very much diluted, is run into it slowly from a graduated burette. At a certain point, the sugar decomposes the solution of copper, the blue colour disappears, and solid bright red particles, which are cuprous oxide or protoxide of copper, appear in the basin. The operation is then ended. You measure the quantity of wine consumed to bring about this result, and you calculate the quantity of sugar which is thereby indicated.

141. This operation serves to test *Grape Sugar* in wine, but it has no action upon *Cane Sugar*. If both are present in the same liquor, the grape sugar alone is indicated, and it is only possible to bring the cane sugar under the power of the test by first converting it into grape sugar. I shall presently explain how that is to be done; but it is of

little importance to the tester of wines, for on testing the 41 wines that are enumerated in Table I. I have not in a single instance found cane sugar, though I have many times searched for it. The reason I take to be this, that cane sugar cannot remain as such for any length of time in wine or any acid liquor, but becomes converted into grape sugar, and is found as grape sugar in the wine.

THE APPARATUS USED IN TESTING WINES FOR SUGAR.

142. The most essential parts of this apparatus are represented in Fig. 21, page 76. A and B represent the same burette and support that have been described at page 62. D is the small furnace represented by E in Fig. 7, page 51, and which is heated by the gas burner, or the spirit lamp, that are figured at page 52.

Letter C, Fig. 21, represents a white glazed Berlin porcelain evaporating basin, of $4\frac{1}{2}$ inches in diameter, which is fitted into an iron ring so as to confine the direct heat of the lamp to the middle of the bottom of the basin, and prevents its heating the sides or upper part of the basin. Graduated flasks, having one mark on the neck, like Fig. 18, page 64, and of the capacity of 100, 200, and 500 septems respectively, are required for the dilution of wines to particular standards.

TEST LIQUORS FOR SUGAR.

143. COPPER TEST A. This contains 433.125 grains of pure crystallised sulphate of copper dissolved in water to form 1 imperial pint of solution.

COPPER TEST B. This contains 2166 grains of tartrate of potash and soda, and 1010 grains of pure caustic soda, both dissolved in water to form 1 imperial pint of solution.

These two liquors should be contained in closely-stoppered glass bottles, in a cool and dark place, and they keep longest in good condition when preserved in small bottles, quite full.

PREPARATION OF WINES FOR TESTING. SEPARATION OF COLOURING-MATTER AND FREE ACID.

144. The following preparations are required for this purpose:—

1. *Slaked Lime* mixed with water into milk or very thin paste.
2. *Alum liquor*, containing half an ounce of pure crystallised alum in 10 ounces of solution.
3. *Sub-Acetate of Lead* prepared as follows: Take 4 ounces of pure acetate of lead, 3 ounces of litharge free from copper, and 4 ounces of water. Boil them together in a bottle or beaker for half an hour, replacing the evaporated water, and continually stirring or shaking the mixture. Filter the product when sufficiently cooled, and dilute it in the mixing jar, Fig. 16 C, to 1000 septems.
4. A solution of pure *Carbonate of Soda* in water.

APPLICATION OF THESE DECOLORING MATERIALS.

145. The wine to be tested for sugar should be so much diluted with distilled water that about 50 septems of it will contain half a grain of sugar. The copper test does not give accurate results when used with strong solutions of sugar. The extent of the dilution of the wine depends therefore upon the character of the wine—upon its proportion of sugar, the depth of its colour, its quantity of tannin, &c. The following directions will serve to guide the operator in most cases:—

FLASK *a*. Wines that are rich in sugar, Tokay, Champagne, &c., such as Nos. 15, 16, 17, 28, and 35, in Table I., may have 5 septems diluted with water to 500 septems. The 5 septems must be measured with scrupulous care.

FLASK *b*. Port, Sherry, Madeira, Como, and other wines of strong colour, may have 10 septems diluted to 200 septems.

FLASK *c*. Light wines, containing very little sugar, both red and white sorts, may have 50 septems diluted to 100 septems. But if the colours are strong, the dilution must be greater.

146. These quantities of diluted wine will be enough to complete an experiment. The wine is, in each case, to be measured into a graduated flask, but only half of the dilution water is to be used at first. A portion of milk of lime is then to be added and thoroughly shaken up with the wine. There should be enough lime used to render the mixture alkaline when tried with a glass rod and a slip of red litmus test paper.

The solution of lead is next to be added, in quantity equal to about one-tenth part of the bulk of the wine used. That is to say, to the wine in flask *a*, half or three-quarters of a septem may be added; to that in flask *b*, one septem; and to that in flask *c*, five septems. The mixtures in the flasks are again to be shaken, and then the alum liquor may be added, in quantity equal to about one-third part of the bulk of the lead liquor that is used. A little more water is to be added to each flask; the mixtures are to be thoroughly shaken; filled up with water to the mark on the neck, namely, flask *a* exactly to 500 septems; *b* to 200 septems, and *c* to 100 septems; and then, being once more shaken, are to be set aside that their precipitates may settle down. After some time, the upper part of each liquor will be observed to be tolerably clear, and a portion can be filtered off through a *dry paper filter* into a beaked tumbler without disturbing the precipitate. It is sufficient to filter merely enough of the liquor to fill the burette A, Fig. 21.

147. Many light-coloured wines require no precipitation with lead, lime, or alum, to prepare them for action with the copper test. It is only necessary to mix them with as much solution of carbonate of soda as renders them alkaline to test paper. In all cases liquors that are to be tried for sugar with the copper test must be made alkaline, because free acid destroys the copper test.

148. In some wines, especially in red wines, the colouring matter and the tannin are so difficult of displacement, that all these additions are required to clear them sufficiently for use with the copper test. But that is not always the case. Some wines can be cleared with the lead liquor without using the slaked lime; others with the lime without the lead. The clearing is often made easily and completely. At other times, a wine that is rendered quite colourless and transparent is still found to retain some ingredient, most probably tannin, which much interferes with the proper action of the copper test. Yet, with all its difficulties, the copper test is the best of all known tests for estimating sugar in wines.¹

PROCESS WITH THE COPPER TEST.

149. Arrange the apparatus as shown by Fig. 21. Clean the burette, fill it with one of the diluted and clarified wines, and adjust the quantity in the burette to zero.

Put into the porcelain basin C, Fig. 21, 10 septems of the copper test A, and 10 septems of the copper test B, and add 30 septems of distilled water. Light the lamp in the furnace D, bring the diluted blue liquor in the basin to the boiling point, and let it boil a few minutes. The liquor must retain its blue colour and no red powder must appear in it. In that case, the copper test is in good order. But the test is liable to spoil when kept long, and the symptom of its being in bad order is, that it gives a precipitate of red copper when boiled with water only. If a precipitate appears, but only in small quantity, it may be removed by an addition of caustic soda solution; but if the precipitate of copper is considerable, or if it will not disappear when solution of soda is added, the test is unfit for use. When the two copper test solutions A and B are mixed in one bottle, they get out of order speedily, which is the reason why they are put into two bottles.

150. Supposing the copper test to be found to be in good order, the analysis of the wine may be proceeded with as follows:—The copper test having been boiled for a few minutes, the heat is to be diminished until the blue liquor barely simmers. The wine from the burette is then to be run into the basin, little by little, the mixture being carefully stirred with a glass rod the whole time. The first

¹ According to Thudichum and Dupré, the foregoing preparatory process is defective, inasmuch as grape sugar, in an alkaline solution, is liable to be partially precipitated by acetate of lead. They therefore recommend that the wine, without being neutralised by lime, should be precipitated by a solution of neutral acetate of lead (prepared by dissolving one part of sugar of lead in ten parts of distilled water); that, after some repose, the mixture should be filtered, the filtrate be shaken up with animal charcoal, and finally be again filtered through a dry filter; after which it is ready for the copper test.—*Origin, Nature, and Varieties of Wine*, 1872, page 227.

action of the test is to render the mixture turbid with a greenish or reddish-brown precipitate, which does not settle readily. As the action proceeds, the precipitate becomes of a more decided red colour, and towards the end of the operation it settles down more readily, and the liquor finally becomes colourless. The protoxide of copper in brilliant red powder is then seen at the bottom of the basin. During the whole period of testing, the mixture is to be kept gently simmering. You should, from time to time, after stirring the liquor, allow the precipitate to settle, and then turn the basin a little on one side, that you may see the blue tint of the liquor against the clean white side of the basin. Occasionally the basin must be removed from the furnace, that the liquor may cease to simmer, and, by cooling, permit the precipitate to fall down. When the blue colour of the liquor becomes faint, you must take care to add the wine only in single drops, in order not to overdose it. Finally, one or two drops of the wine take away the last residue of the blue colour, and the bright red precipitate settles down in the clear liquor. The operation is then ended.

These changes of colour are seen very beautifully when only grape sugar and water are present in the testing liquor. But the tannin and other organic matters that remain in the wine, notwithstanding its attempted clarification, and, indeed, the residue left in the mixture by the substances employed to clarify the wine, disturb the action considerably. They produce a brown liquor or a bulky mass in the basin, when it ought to be colourless and clear, and they sometimes keep the copper in suspension as a yellowish-brown powder, and so prolong the operation; but by keeping up the gentle heat that is required, and by stirring this powder, the operation comes at last to the conclusion described above; the liquor becomes clear and free from blue colour, and a heavy powder of a brilliant red colour appears at the bottom of the basin.

CALCULATION OF RESULTS.

151. The 10 SEPTEMS of copper test, included in the two solutions A and B, with which the testing of the wine is executed, contain a quantity of copper, the reduction of which to the state of red oxide requires exactly *half a grain of Grape Sugar*. Consequently, the number of septems of diluted wine that were passed from the burette to the basin during the operation, and which is indicated on the graduated scale, show *how many septems of the diluted wine contain half a grain of grape sugar*. The next point to take into consideration is the state of dilution of the wine that was submitted to trial. According to the directions given in § 145, the dilution was—

In flask *a*, 1 measure to 100 measures,

In flask *b*, 1 measure to 20 measures,

In flask *c*, 1 measure to 2 measures.

Example 1.—A wine in flask *a* reduced the copper with 29·4 septems of the diluted wine. Doubling that number, we have 58·8 septems as the equivalent of 1 grain of sugar. But as this wine was diluted from 1 to 100, the true equivalent is obtained by removing the decimal point of the number two places to the left: this gives us ·588 septems as the quantity of undiluted wine that contains 1 grain of sugar. Then, to find the quantity of sugar in a centigallon, we take this proportion:—

$$\begin{aligned} \cdot 588 : 1 &= 100 \cdot 000 : x. \\ x &= 170 \cdot 07 \text{ grains.} \end{aligned}$$

This was the testing of Visanto, No. 16, Table I.

Example 2.—A wine in flask *b* reduced the copper with 37 septems of the diluted wine. This is equal to 74 septems for 1 grain of sugar, and as this wine was diluted from 1 to 20, we have $74 \div 20 = 3 \cdot 7$ as the quantity of undiluted wine that was equal to 1 grain of sugar; and then, to find the quantity of sugar contained in a centigallon, we take, this proportion:—

$$\begin{aligned} 3 \cdot 7 : 1 &= 100 \cdot 0 : x. \\ x &= 27 \cdot 03 \text{ grains.} \end{aligned}$$

This was the testing of Madeira, No. 4, Table I.

Example 3.—A wine in flask *c* reduced the copper with 85 septems of the diluted wine. This is equal to 170 septems for 1 grain of sugar; and as the wine was diluted from 1 to 2 only, the quantity of undiluted wine equal to 1 grain of sugar is precisely the same as the number shown on the scale of the burette, namely, 85 septems; so that for wines of this degree of dilution the calculation is very simple. To find the quantity of sugar contained in a centigallon of such a wine we use this proportion:—

$$\begin{aligned} 85 : 1 &= 100 : x. \\ x &= 1 \cdot 18 \text{ grains.} \end{aligned}$$

This was the testing of Rudesheimer, No. 41, Table I.

The numbers given in Table I, column 9, were all determined by the processes that are here described.

CANE SUGAR.

. 152. I have explained at page 77 the difference in the composition of grape sugar and cane sugar. I have stated there that cane sugar cannot be tested with the copper test, and that I have never found cane sugar in wine.

It is, however, quite possible for it to exist in wine that has been very recently adulterated with it, and I have found it in large quantities

in London gin which was free from acid. It is necessary, therefore, to show in what manner it is to be sought for when its presence is suspected, and how its quantity can be determined when its presence is proved.

I shall suppose that you have a wine that contains both grape sugar and cane sugar, and that you have estimated the grape sugar by the process described above. You have then to proceed as follows in order to convert the cane sugar into grape sugar, and make it sensible to the copper test.

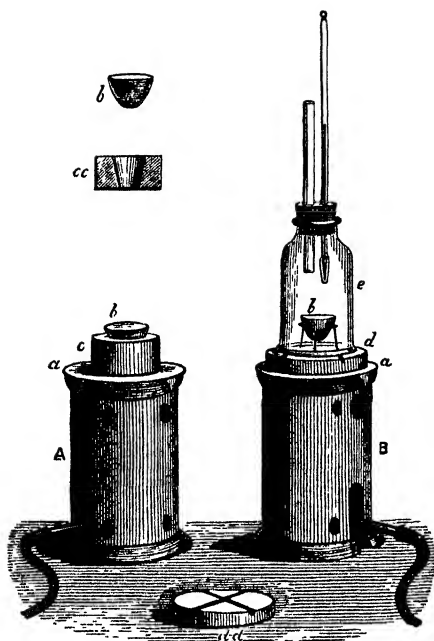
Put 50 septems of the undiluted wine into a boiling flask, add 10 septems of diluted sulphuric acid containing 1 measure of oil of vitriol to 5 measures of water, and gently boil the mixture for at least two hours on the furnace D, Fig. 21. Let it cool, add a solution of carbonate of soda, in quantity sufficient to neutralize the sulphuric acid and to cause the mixture to be alkaline to test paper, and then dilute it largely, as above described, according to the character of the wine; if necessary decolour it by adding the lead liquor, and proceed to test it as if it contained grape sugar.

The action of diluted sulphuric acid at a boiling heat upon cane sugar is to change it into grape sugar; and this change takes place in such a manner that one atom of cane sugar weighing 342,—see page 77,—takes up one atom of water weighing 18, and produces 12 atoms of grape sugar, weighing 360 ($= 30 \times 12$). According to this theory 1 part of cane sugar produces 1.053 part of anhydrous grape sugar, or .95 of cane sugar produces 1.00 of anhydrous grape sugar.

The conversion of cane sugar into grape sugar by the action of sulphuric acid at a boiling heat in a couple of hours, is an action similar to that which is attributable to tartaric and other acids when acting for a long time at a low temperature. And this is the reason that, in acid wines that have rested quietly for many months, we find no trace of cane sugar, but only grape sugar of the composition represented by the formula CH^2O .

In the event of the presence of cane sugar in conjunction with grape sugar, the latter is first determined, and its ascertained amount is deducted from the amount produced by testing another portion of the wine after it has undergone the process for the conversion of its cane sugar into grape sugar; for during this conversion of the cane sugar, the grape sugar continues in the mixture unchanged.

I have made no mention of *Fruit sugar*, which accompanies grape sugar in wines; because it has the same composition as grape sugar, and it behaves in the same way towards the copper test.



**EXPERIMENTAL DETERMINATION OF THE AMOUNT OF SOLID
RESIDUE LEFT WHEN WINES ARE EVAPORATED TO
DRYNESS AT 230° FAHRENHEIT.**

**DESCRIPTION OF THE APPARATUS USED TO EVAPORATE A WINE TO
DRYNESS.**

155. Fig. 22 A represents a stoneware cylindrical furnace, containing a rose gas-burner, like Fig. 9, page 52, or a spirit lamp with rack, like Fig. 10. Fig. 22 *a* is an iron cover with a hole in the middle. *b* is a Berlin porcelain crucible, glazed within and without. It measures $2\frac{1}{2}$ inches in diameter, and it is capable of holding one ounce of water. *c* is a cylinder of fire clay, about 3 inches in diameter and 2 inches in height. It has a conical perforation, which adapts it to the crucible *b*, as shown in the figure; *cc* is a section of this cylinder. In this apparatus the wine is slowly evaporated till it is *nearly* dry.

Fig. 22 B and *a* represent the same furnace, with additions. *d* is a circular plate of fire clay, half an inch thick and 5 inches in diameter. A double groove in the form of a small cross is cut in the upper surface of this plate, as shown by the separate figure *dd*. *e* is a glass cylinder, open and flanged at the bottom, and having a wide neck at the upper end. In that neck is fitted a cork that carries a thermometer and a glass tube open at both ends. Within the glass cylinder is a slight tripod of copper wire, which holds the crucible in the middle of the cylinder and at about 2 inches from the clay plate.

PROCESS OF EVAPORATION.

156. The crucible *b* is to be made perfectly clean and dry, and to be weighed with its cover, and a note is to be taken of the weight in grains. 50 septems of the wine, carefully measured by a pipette, at 60° Fahr., are to be put into the crucible, and the crucible is to be adjusted over the furnace A, as represented in the figure. Heat is then to be applied with caution, so as to warm the wine and cause it to give off steam; but the heat must never cause the wine to boil, not even to simmer, because the loss of drops by spirting, that would then be occasioned, would spoil the experiment. The cylinder of fire-clay becomes hot and applies a regulated heat to the crucible, but the heat that rises directly from the gas or spirit burner touches only the bottom of the crucible and not the sides. The consequence of this arrangement is, that in proportion as part of the wine is evaporated, the residue subsides to the bottom of the crucible, and is not dried in films and burnt on the sides of the crucible, as is the case when the crucible is entirely exposed to the hot gases that rise from any flame.

When the wine is nearly all evaporated, care must be taken not to continue the heat too long, or to suffer it to rise too high, otherwise the residue will be burnt and the operation be spoilt. When the wine is *nearly* dry, or as dry as it can be made at 212° Fahr.—it happens in many cases that the residue is a liquid which cannot be made solid at 212° Fahr., but which, after being for some time heated at that temperature, becomes solid when it is allowed to cool. It is, however, very difficult to dry these residues thoroughly; and as the apparatus described above as furnace A affords no means of determining the degree of heat at which the drying is effected, we stop the process of evaporation before it is quite accomplished, and proceed to effect the completion of the drying at a determinate temperature by means of the apparatus that is represented in Fig. 22 by the furnace B, with its superstructure.

DRYING THE RESIDUE AT 230° FAHR.

157. The crucible, with its contents already nearly dried over the furnace A, is put into its proper position over the furnace B. The gas or spirit burner is ignited, and the thermometer is watched until it

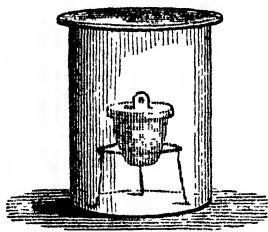
indicates 200° or 212° Fahr. The heat is then to be lessened, and the thermometer watched until it rises to 230° Fahr. The gas, or the rack work of the spirit lamp, must then be turned down, until the thermometer remains stationary at 230° Fahr., which point, corresponding to 110° centigrade, is adopted by many chemists as that at which these evaporations can be most conveniently completed. If the heat rises too high, it can be immediately reduced by lifting the glass cylinder *e*; if it goes too low, the flame in the furnace must be enlarged.

The cross grooves that are cut in the clay-plate *d*, and the open glass tube that is fixed on the mouth of the glass cylinder, serve to promote the drying of the substance contained in the crucible, by causing a rapid current of air to pass through the apparatus, entering by the grooves and escaping by the glass tube. This current of air carries off the vapour that rises from the crucible.

The time during which the residue in the crucible ought to be exposed to the temperature of 230° Fahr., to insure a perfect drying, depends upon the quantity and coherence of the residue. It may vary from an hour to an hour and a half; and when it is desired to have results of especial accuracy, the crucible, after-being cooled and weighed in the manner to be presently described, should be returned to the furnace B, and dried for another half hour or hour at 230° Fahr., and be again cooled and weighed to ascertain if any farther evaporation has occurred. The rule with chemists in such cases is to dry and weigh, dry and weigh repeatedly, until no difference in weight is to be found in two successive weighings. Of course such a process is tedious, and it is left to the judgment and patience of the operator to repeat it as often as he thinks it.

COOLING AND WEIGHING THE RESIDUE.

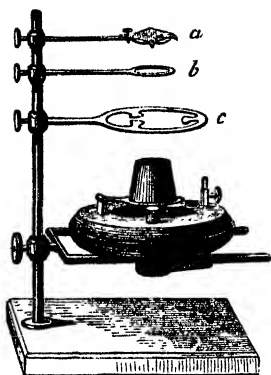
158. When the residue is considered to be sufficiently dried, it must be weighed; but before it is weighed it must be cooled, because a hot crucible cannot be weighed with accuracy. The residue dried at 230° Fahr. has a strong tendency to take up water from the air, which must, as much as possible, be prevented. To this end, when the crucible is taken from the furnace, which is to be done with the help of a pair of crucible tongs, it is to be put into the apparatus represented by Fig. 23. This consists of a glass cylinder, which has a flat bottom and a ground edge. Upon the bottom is placed a trivet of copper wire of a size to



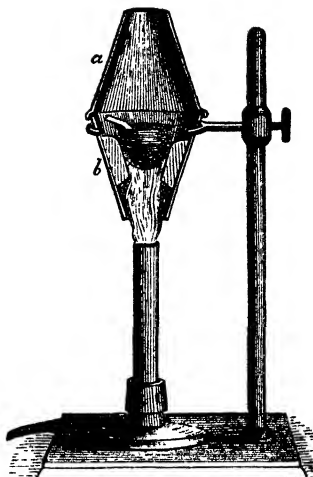
hold the crucible. The cylinder is closed by a round disc of glass ground on one side. The edges of the cylinder and the ground side

of the cover are greased with tallow to cause them to fit together air-tight. The bottom of the cylinder may be covered with oil of vitriol to the depth of an inch, to absorb moisture, but this precaution is scarcely necessary. I have not used it. The cover must be put on the crucible as soon as the crucible is placed in the cooling apparatus.

When the crucible has become cold, it must be weighed with the balance and weights described at p. 15. The weight of the crucible, its cover, and its contents, being determined in grains, the weight of the crucible and cover previously determined, § 156, is to be deducted, and the remainder is the weight of the solid residue of the wine dried at 230° Fahr. In this manner the numbers given in Column 10 of Table I. were determined. When the weighing is completed, and it has been determined not to dry the residue any longer, it is set aside for use in the determination of the quantity of ash.



24.



25.

EXPERIMENTAL DETERMINATION OF THE QUANTITY OF INCOMBUSTIBLE SUBSTANCES IN WINES.—THE ASH.

160. The *ASH*, or *Incombustible Substance*, contained in a wine, is obtained by subjecting the *dried Residue* to the action of a strong red heat. The sugar, the tartaric acid, the tannin, and other organic matters burn away, and the incombustible matters remain in the crucible and can be weighed.

161. *APPARATUS REQUIRED*.—A pretty strong heat is required to burn completely the large quantity of residue that is left by the sweet wines. The small gas burner or spirit lamp that serves for distillations and for evaporations to dryness will not serve for calcinations. The operator must for this purpose be provided with a more powerful gas burner, or with a spirit lamp constructed on the Argand principle. The necessary apparatus is represented by Figs. 24 and 25.

162. *PROCESS OF CALCINATION*.—The crucible containing the dried residue of the wine—(see § 158) is placed, without its cover, in the body of the crucible jacket, *b*, Fig. 25, where it is supported by three upright edges of iron. The crucible jacket is adjusted at such a height above the gas burner or the spirit lamp as will enable the flame,

when it is in full action, to cover the entire crucible; but, of course, the heat is at first to be applied very gently, in order not to break the crucible, and is to be gradually raised. The cover *a* of the crucible jacket *b* serves to increase the draught of air, and to render the action of the flame more effective.

163. The organic matters in the residue are speedily charred, but the conversion of the charcoal into carbonic acid, and its consequent dispersion in the state of gas, is not so easy. The combustion proceeds only in proportion as oxygen finds its way into the crucible and combines with the charcoal. To facilitate the requisite access of oxygen, it is proper to make the following addition to the calcining furnace. *a*, Fig. 26, is a slip of platinum foil, about 3 inches long and $\frac{1}{2}$ inch wide, which is bent lengthways into a ridge and turned over at the end, and is then placed in the crucible. The overhanging end of this gutter catches the rising air mixed with burning gas and causes a portion to descend into the crucible and sweep over the red-hot charcoal, which it gradually oxidises and carries away. The operation lasts a considerable time, more or less, according to the amount of the residue. Such residues as are rich in sugar, like Nos. 15, 16, 17, 28, 35, in Table I., may require 30 to 40 minutes for their combustion. The smaller residues from 20 to 30 minutes. The operation is not completed while any portion of black charcoal remains visible in the crucible. The colour of the ash, when fully calcined, depends upon the nature of the mineral constituents that occur in the ash. It is rarely white; generally it has a grey tinge; sometimes it is red from the presence of a quantity of oxide of iron, and sometimes is made green by a little manganese.

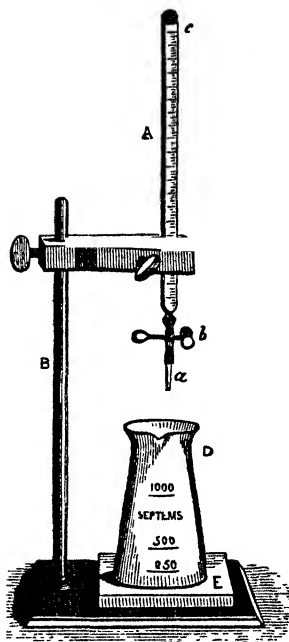


26.

164. When the calcination is considered to be complete, the gas is to be extinguished, and the crucible suffered to cool partially. It is then to be taken from the furnace by the crucible tongs, and the ash is to be gently stirred with the slip of platinum foil, to see if it contains any residue of charcoal. If it does, it must be again ignited; if it does not, the crucible, with its cover, is to be placed in the cooling apparatus described at p. 86, and when it is sufficiently cool it is to be weighed. After the weight is registered, the ash is ready for the operation described in the next section.

The numbers in Column 11 of Table I. were determined by the above process.

The calcination of organic matters is very readily and perfectly effected by the use of Mr. CHARLES GRIFFIN'S *Gas Muffle Furnace*.



27.

EXPERIMENTAL DETERMINATION OF THE QUANTITY OF FREE ALKALI CONTAINED IN THE ASH OF WINES.

165. The Ash of Wines, estimated as to quantity by the process last described, is a very mixed substance, containing several acids and several bases of a mineral character, the separation of which from one another, and the accurate determination of each by weight, would require the performance of a chemical analysis of a complicated character, demanding more time and attention and much larger quantities of wine than all the foregoing processes taken together. I shall quote an account of some analyses of such ashes, to show the bearings and extent of the subject.

166. No. 1 in the following list was the ash from the juice of unripe blue grapes which had grown on a porphyry soil. No. 2, ripe grapes of the same kind. No. 3, ripe blue grapes grown on a calcareous marl. No. 4, ripe green grapes from a porphyry soil. No. 5,

was ash from fermented grape juice or wine. The first four analyses were executed by Crasso. The fifth by Boussingault. See *Handwörterbuch der reinen und angewandten Chemie*, Band ix. S. 676.

	1.	2.	3.	4.	5.
Ash, per cent. . . .	0.26	0.34	0.41	0.29	0.18
Potash	65.5	63.9	71.3	62.0	45.0
Soda	0.3	0.4	1.2	2.6	..
Lime	5.2	3.4	3.4	5.1	4.9
Magnesia	3.3	4.7	4.0	4.0	9.2
Ferric Oxide	0.7	0.4	0.1	0.4	..
Manganic Oxide . . .	0.8	0.7	0.1	0.3	..
Phosphoric Acid . . .	15.4	16.6	14.1	17.0	22.1
Sulphuric Acid . . .	5.2	5.5	3.6	4.9	5.1
Silica	2.0	2.1	1.2	2.2	0.3
Potassium Chloride . .	1.5	2.1	1.0	1.5	..
Carbonic Acid . . . .	..	..	..	..	13.3

167. The numbers given in Column 12 of Table I. do not express the results of an accurate analysis of the ash, but merely an estimate of the amount of the free alkalies contained in it, which estimate is deduced from a volumetric process as follows:—

168. The test liquors required are the standard nitric acid, § 114, and the standard ammonia, § 107. The weighed ash, § 164, still remaining in the crucible, is to be washed out of it with distilled water, into the mixing jar D, Fig. 27. If it adheres to the crucible, the crucible with the water may be heated over the spirit lamp till the hot water loosens the ash completely. When the ash is all brought into the mixing jar, ten septems of standard nitric acid, carefully measured with a pipette, are to be slowly dropped into the mixing jar, which must in the mean time be shaken to facilitate the disengagement of the carbonic acid that is set at liberty by the nitric acid. When the nitric acid is all added, the mixing jar may be heated over the furnace E, Fig. 7, page 51, until the mixture gently boils, in order to drive off the carbonic acid completely. It is then necessary to add a measure of hematine test liquor, § 117. This, when mixed with the solution, should give it a pale-yellow colour. If it does not it is necessary to add 5 septems more of the standard nitric acid, and to repeat the boiling. This addition of acid will, however, be rarely necessary. The yellow colour produced by the hematine test shows that nitric acid is present in excess. A certain amount of muddiness appears in the liquid in consequence of the

presence of salts that are neither soluble in water nor in nitric acid. That muddiness is to be disregarded.

The liquor being thus prepared, the burette A, Fig. 27, is to be filled with standard ammonia, and the free nitric acid in the mixing jar is to be neutralized with the ammonia test, precisely in the same manner as the free acid is neutralized in wines. Note the number of septems of ammonia test required to neutralize the free nitric acid.

Calculation of Results.

169. Deduct the septems of ammonia test used from 10 or from 15, the number of septems of nitric acid used—the residue is the number of septems of nitric acid that correspond to the free alkali that is extracted from the ash and neutralized by the acid. I have reckoned this alkali in Column 12 of Table I. as hydrate of potash. The number which corresponds to that alkali, according to the table given at page 67, is $\cdot 03734$. That is to say, the septems of nitric acid used to saturate the alkali, when multiplied by $\cdot 03734$, gives the equivalent of hydrate of potash in grains. This is the number that is given in Table I., Column 12.

170. In order that this matter may be fully understood, I must explain some points in regard to it a little more at length. The free alkali in the ash is not hydrate of potash, but a mixture consisting chiefly of carbonate of potash, with a little carbonate of soda and some lime and magnesia. The two latter may, in cases where the calcination of the ash has been readily effected, be in the state of carbonates; but when the calcination of the residue has required a strong and long-continued ignition, the lime and magnesia will be more or less deprived of carbonic acid, in which condition the lime is soluble in water. But for this circumstance, the potash and soda could be washed with water away from the lime and magnesia, and be tested by themselves, the earths being afterwards dissolved in nitric acid and tested apart from the alkalies. If the operator feels desirous of making this distinction between the alkalies and the earths, he may come to accurate results by first adding to the ignited ash a solution of carbonic acid in water, which will convert the earths into carbonates and render them insoluble in the water that is used to extract the alkalies.

171. The phosphates, the sulphates, and the chlorides contained in wine can all be estimated by volumetric processes by those who desire to pursue this branch of the subject more thoroughly. Instructions for such researches will be found in my work entitled *Chemical Handicraft*. Those who wish to make a complete analysis of the mineral constituents of wines, as tabulated at page 91, will have to follow the rules laid down in works that treat especially of the quantitative analysis of mixed minerals, such as the Handbooks of Analytical Chemistry by Rose

and Fresenius; or they may consult THUDICHUM and DUPRÉ's *Treatise on Wines*, in which the subject is treated pretty fully.

A great deal has been said in advertisements about the importance of phosphorus in wines; but when the facts are examined, it appears that occurring with phosphates, which is the state of combination in which phosphorus is found in wines, it requires from 1000 to 2000 parts of wine to yield 1 part of phosphoric acid. Sufficient evidence of this fact is given in the tables quoted above. Whether this homœopathic dose of phosphoric acid is important or non-important in a hygienic sense, I do not know. If it is really important, it is capable of being estimated in every analysis of wine if you use plenty of wine and patience. But it is needless to seek in wines for uncombined phosphorus, for its presence is impossible.

ESTIMATE OF THE NEUTRAL ORGANIC BODIES CONTAINED IN WINES.

172. I have given in Column 13 of Table I. a series of numbers which represent approximately the weight of the neutral organic bodies that are found in certain wines. These numbers do not express experimental results, but are arrived at by a series of calculations. They cannot be relied on for accuracy; but as approximations they are worth consideration, as long as accuracy is unattainable.

173. The numbers in Column 10 of Table I. give the total weight of what is left in a solid state when a wine is evaporated to dryness, and the result heated to 230° Fahr. The mixture contains the sugar, the free acid that remains unvolatilized at 230° Fahr., the mineral salts or ash, a certain quantity of acids united in a neutral condition with the alkalies and earths; and, besides all these, a considerable quantity of organic matter, which is not acid, not alkali, not sugar, not mineral, but which is of a neutral character, and is of almost unknown composition. Its quantity varies in different wines, but, as is manifest from the numbers in the Table, is in most wines very considerable.

174. In attempting to ascertain the weight of this NEUTRAL BODY contained in each wine, I have deducted from the numbers quoted in Column 10 of Table I. the four following numbers:—

- a. The amount of sugar, as given in column 9.
- b. The amount of fixed free acid. For certain wines, this amount was taken from Table IX., given in page 73. For the other wines, of which I had made no fractional analysis, I obtained a number for the free fixed acids at $\frac{1}{100}$ by multiplying the numbers given in column 6 of Table I. by .712; this number affording the average proportion of the fixed to the volatile acid.
- c. The amount of ash, as given in column 11.
- d. The amount of tartaric or other fixed acid assumed to be combined with the alkalies and earths estimated by the numbers given in column 12. As the accurate estimation of this acid is impossible, on account of the mixed state of the alkalies, I contented myself with representing it by the same number as is used in column 12 to represent the alkalies.

Deducting these four quantities from that represented by the numbers given in column 10, I obtained the quantities of neutral organic bodies that are represented by the numbers given in column 13. These quantities are in some instances very large. There can be no doubt that they often influence the taste and properties of wine considerably, and

it is to be lamented that no ready methods of discriminating the components of these neutral matters have been made known. All the following substances are said to have been found in wine by different investigators; namely, gum, wax, resin, fat, glycerine, pectin, pectose, albumen, cellulose, lignin, chlorophyll, blue colouring matter, yellow colouring matter, and above all, and sometimes including all, *extractive matter*. Besides these compounds, chemists and microscopists seem to have lately discovered in wines an extensive series of microscopic vegetations, which produce in wines all sorts of striking effects, some useful, some mischievous; one of these vegetations causes the vinous fermentation, another the acetic fermentation, another the lactic acid fermentation, while others produce bitterness, ropiness, and wine diseases of various descriptions. I did wrong, therefore, in saying that the neutral organic matter was of unknown composition; for here is an abundance of knowledge. I meant to say, that the existing chemical knowledge of the neutral organic bodies contained in wines was not of a kind or in a condition to be, as yet, convertible into testing operations for the beneficial use of wine merchants, wine makers, or wine consumers.

CONSTITUENTS OF WINES, THE AMOUNT OF WHICH CANNOT BE TESTED BY CHEMICAL EXPERIMENTS NOR ESTIMATED IN FIGURES.

COLOURING MATTER—TANNIN—BOUQUET.

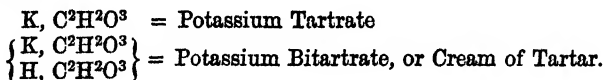
175. I can give no chemical tests for these matters, and, therefore, in a practical work, such as the present, it is useless to say much about them.

None of the Tests which have been recommended, to distinguish the true COLOURING MATTER of wines from the colours mixed with them, appear to me to be of any value.

TANNIN can be precipitated by solutions of isinglass and gelatine, but not in such a manner as to give practical and decisive results that can be expressed in figures. It can also be indicated by a solution of ferric chloride, which gives a black tinge to the wine; but this is so mixed with red and brown tints, and is so changeable, that the result cannot be expressed in figures.

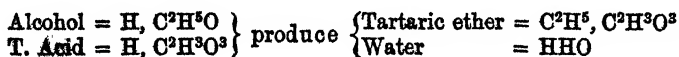
For the BOUQUET there is no chemical experiment that can compete with the nose and mouth of the WINE TASTER. It is impossible to weigh or measure the constituents which produce bouquet. I may, however, be permitted to add a few words respecting the *nature* of those constituents, though even this is of little importance at a time when chemists who experiment and write upon the subject express the most contradictory views.

The formula of tartaric acid is this: $\text{H, C}^2\text{H}^2\text{O}^3$. This acid produces two kinds of salts, neutral and acid, of which the following are examples:—



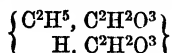
This last salt in solution acts against tests for acidity like one atom of tartaric acid, which atom it contains in the state of hydrate, the salt of potassium being neutral to test papers and to alkalies, whether it exists in the free state or in the state of bitartrate.

When tartaric acid is in solution with alcohol, the following combination can take place, in a day or two if the materials are sealed up in a glass tube and strongly heated, and in a year or two at a low temperature in a wine bottle:—



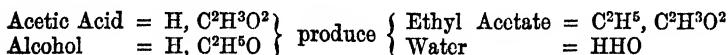
namely, an atom of ethyl = C^2H^5 , combines with one atom of tartaric acid, rejecting an atom of hydrogen, which produces water by combining with the residual hydrogen and oxygen of the alcohol that yielded the ethyl.

This tartaric ether, or tartrate of ethyl, being produced in the presence of an excess of hydrated tartaric acid, combines with another atom of it and produces a double salt having this formula:—



which salt is the equivalent of the bitartrate of potassium cited above. This double salt, the bitartrate of ethyl, seems to be largely produced as wine becomes old, and its production has the effect of making the wine appear to be less acid than it was before the production of this salt; for that atom of tartaric acid which is combined with the ethyl is neutralised, or loses its acid power, both against chemical tests and the power of taste. It is impossible to separate this ethereal salt from the wine for the purpose of ascertaining its quantity; for, on attempting to distil the wine in which it exists, decomposition again takes place, water is taken up, and the salt is restored to the original condition of alcohol and tartaric acid.

Other acids that occur in wine can also combine with alcohol and produce ethers. Thus, acetic acid produces an ether by the reactions described in the following equation:—



The acetate of ethyl does not combine with another atom of hydrated acetic acid to produce a double salt like the bitartrate of ethyl. It remains in the state of neutral acetate. It differs also from the tartaric ether in being volatile, so that when wine which contains it is distilled, the acetic ether passes over with the alcohol into the distillate, where it can be detected by its odour, but cannot be measured as to its quantity.

Malic, succinic, pelargonic, and other acids no doubt also produce ethers by acting on the alcohol of wines.

Thus it is, that as wines grow old, these ethers are produced in them; and to these ethers is no doubt attributable all the odours of the wines and much of their flavour.

Such is the Theory of Bouquet, which appears to me to be most consistent with our present knowledge of the constitution of wines. I give only this slight notice of the subject, because a lengthened disquisition would lead to no practical conclusion. To write about the causes of bouquet is to travel over a vast meadow of conjecture watered by only a narrow streamlet of fact.

PROGRAMME OF A WINE ANALYSIS ACCORDING TO THE METHOD DESCRIBED IN THIS WORK.

176. The analysis of a wine, performed in such a manner as to elicit a series of facts such as are recorded in Tables I. and II.—the application of the tests, with the subsequent calculations—occupies about six hours; the estimation of alcohol, acid, and sugar, about three hours. But to go properly through the operations in that time, there must be system in the procedure. The following programme shows how the operator should go through the work.

Before commencing an analysis, the necessary apparatus must be all put ready in good condition, and the glass vessels be made perfectly clean and dry. There should be a good supply of distilled water at hand.

A. Put about 8 fluid ounces (500 septems) of the wine into a tall, thin beaker glass. Take the temperature of the wine with the thermometer, § 15. If it is above 60° F., it must be cooled to that degree. For this purpose, put the beaker into another larger beaker, or into a basin containing water mixed with pounded ice, keeping the thermometer in the wine, and watching the fall of the mercury. When the degree is 60°, take the beaker from the ice and place it on a wooden table, where it will remain at 60° while the following measurements are performed.

B. Rinse the specific gravity bottle, § 7, with the wine, and then fill it accurately to the mark in the neck that indicates 100 septems. Take care not to wet the outside of the bottle. Put in the stopper tightly, and it will be ready for weighing. See K.

C. Measure 50 septems of wine into the porcelain crucible that is to be used for evaporating to dryness, § 155. See H.

D. Measure off 5, 10, or 50 septems of wine for the sugar-test, a quantity variable according to the circumstances described at § 145, page 79. See I.

E. Measure two portions of 10 septems each, into two conical mixing-jars for the acid test. See § 119, page 68. See M.

F. Put 50 septems of the wine into the retort that is to be used for the distillation of the alcohol. See § 73, page 52. See J.

G. Put 50 septems into another retort, to be used for the fractional distillation of volatile acid. See § 127, page 71. See Q.

The above quantities of wine are all that are necessary for one set of experiments; but any of the processes may be repeated to insure greater correctness.

H. Set the wine in the crucible C, over the furnace, Fig. 22 A, as directed in § 156, page 85, that the evaporation may proceed while other work is being done. See O.

I. Decolourise the wine for the sugar test (see D), by the method described at § 145, page 79; making the measure up to 500, 200, or 100 septems, as there described, and leave the mixture to settle. See N.

J. To the wine, F, add caustic soda, water, and tannin, and set up the apparatus ready for distillation, as described in § 70 to 79, but without applying heat. See L.

K. Examine the specific gravity bottle, B; and if it is in proper condition, weigh it, take a note of the weight, and reckon the specific gravity, as described in § 12 and 13, page 17.

L. The wine is to be poured from the specific gravity bottle; the bottle is to be well washed with distilled water, and then applied to the condenser of the still to receive the distillate of alcohol. Heat is now to be applied to the retort (see J), and the alcohol to be slowly distilled and collected in the specific gravity bottle. See § 80 and 81, page 56.

M. The two measures of wine set aside in conical mixing jars, E, are now to be tested for free acid, by the process described at § 118 to 122. The calculation of results is described at § 123, page 70.

N. The decolourised wine, I, will now be ready for the sugar-testing process. A portion must be filtered through a dry filter, as directed in § 146, page 79, and with this the burette is first to be rinsed, and then to be filled. The testing is then to be performed in the manner directed at § 149, 150, page 80. The calculation of results is described at § 151.

O. If the wine in the crucible is now nearly evaporated to dryness (see H), or brought into the condition of a thick syrup, the crucible is to be placed in the hot-air bath (Fig. 22 c), and dried for an hour or an hour and a half. See § 157, page 85. See R.

P. The distillation of alcohol will by this time be completed. See L, and § 80, 81. The product is to be diluted to 100 septems (see § 82), to be weighed (see § 83), and the product to be calculated according to the directions given in § 84 to 91.

Q. The wine set apart for fractional distillation (G) may be proceeded with as soon as the distillation of the alcohol is finished, and the condenser is at liberty. The process is fully described between § 126 and 132. The product is to be noted in quantities of 50, 30, and 20 septems.

R. The residue in the crucible, heated in the air-bath at 230° Fahr. (O), is now probably dry. It may be cooled in the Desiccator, Fig. 22 page 86, and when cooled may be weighed. See § 158.

S. The weighed residue in the crucible (R) is next to be calcined,

and the weight of the ash is to be determined, as directed in § 160 to 164, page 88.

T. The ash is to be examined for its quantity of potash, as directed in § 165 to 171.

The programme, as above arranged, for saving time in the performance of the operations of a wine test, requires three gas-burners or three spirit-lamps, with their furnaces, to enable the boilings, distillations, &c., to go on simultaneously. Where so many burners are not at hand, the operations that demand heat must go on successively; but, of course, more time will then be taken to execute a single wine test.

When the wine-testing is restricted to the estimation of alcohol, acid, and sugar, the processes marked C, H, O, R, S, T, are omitted.

• **DESIRABLE QUALITIES IN WINES, AND HOW FAR THE
CONSTITUENTS WHICH PRODUCE THEM CAN BE
TESTED CHEMICALLY.**

177. DR. DRUITT'S "*Report on Cheap Wines*" contains a Chapter on the Parts, Properties, and Desirable Qualities of Wines. I shall notice these qualities, in order to point out the extent to which Chemistry can help us in discriminating them, or in tracing the causes which produce them.

1. "The wine should have an absolute *unity*, or taste as one whole."—On this point, the power of tasting is more effective than that of chemical testing. The latter can, within certain limits, determine the proportions of the constituents of a wine, but not ascertain whether they were derived from one source or from several.

2. "Wine should contain a certain amount of alcohol."—On this point, the power and exactness of experimental testing is decisively superior to the indications afforded by taste.

3. "Wine should be slightly sour."—Chemical testing can determine the amount of acidity with exactness, and, within certain limits, distinguish the acidity that is produced by volatile acids (vinegar) from that which is produced by fixed acids (tartaric, &c.). Taste, on the other hand, gives but a crude notion of the quantity of acid, especially in wines that have been sweetened with sugar and fortified with brandy. The chemical test finds the acid under all such disguises.

4. "Sweetness is characteristic of a certain class of wines, while certain other wines are dry, or free from sugar."—Chemical testing can determine the quantity of sugar contained in wines, if not with scientific precision, yet with sufficient exactness for all practical purposes. See the results quoted in column 9 of Table I.

5. "Wines should have a taste free from mawkishness and indicative of stability."—This is not a point for chemical testing. Like the property No. 1, it is for the decision of the mouth alone.

6. "Roughness or astringency is a most important property and belongs to most red wines. In moderate degree it is relished, as sourness is, by a healthy, manly palate, just as the cold souce is welcome to the skin. In excess it leaves a permanent harshness on the tongue."—This taste is substantially a combination of the taste of free acid with that of tannin. According as that or this ingredient predominates, the taste is either sour or rough. The amount of the acid can be chemically tested and

recorded; but that of the tannin, though indicable by solutions of isinglass and ferric chloride, cannot be measured.

7. "The wine must have *body*. This is the impression produced by the totality of the soluble constituents of wine—the extractive, that which gives *taste* to the tongue, and which, as wine grows older, is deposited along with the cream of tartar forming the *crust*."—I question much whether the sense of *body* is not chiefly produced by there being sufficient alcohol to overcome fully the sourness of the free acids in the wine. I shall discuss that point in another section. To what extent the miscellaneous neutral bodies contained in wine affect its taste we cannot ascertain, because we cannot separate and distinguish them. The alcohol and the free acids are amenable to chemical control, but not those fixed neutral bodies of which we know so little. Read the discussion on solid residués between pages 84 and 95.

8. "*Bouquet* is that quality of wine which salutes the nose. *Flavour* is that part of the aromatic constituent which gratifies the throat."—On this matter, the wine-taster must be called in: the chemist can do nothing. When the question is, whether a wine is agreeable or disagreeable to drink, the mouth alone is competent to reply.

9. "The wine must *satisfy*. A man must feel that he has taken something which consoles and sustains. Some liquids, as cider and some thin wines, leave rather a craving, empty, hungry feeling after them."—It appears to me that this sense of emptiness results from the insufficiency of the alcohol to cover the sourness of the acids present in the wine. It *may* also result from the want of *body*. See No. 7, *above*.

178. From the above review it appears that, on points respecting the taste and odour of wines—the agreeableness of the drink—the mouth and nose are the only competent judges; but that, as respects the estimation of the quantities of the chief constituents of the wines—the alcohol, the acid, the sugar, the fixed residue, and the earthy salts—chemical testing greatly excels in power and precision any indications that mere tasting can afford. I have gone through these details because WINE TASTERS seem for the most part to be of opinion that, since chemistry cannot tell whether the taste of a wine is agreeable or disagreeable, therefore chemical testing is of no use at all. That opinion is founded upon a misapprehension of the office of chemistry, which is not to point out whether a wine is fit or not fit to drink, but to determine *what are the things or circumstances which cause wines to be fit or unfit to drink*—to bring these things or circumstances under scientific control, and oblige them to submit to modifications that will enable the wine-maker and wine-merchant to avoid the losses that arise from the ignorant manufacture of bad wines, or the running of good wines to waste. Wine-making is strictly a chemical manufacture. Every step of it ought to be watched, as are the processes of every ordinary chemical

manufacture. The grape-juice, as soon as pressed, should be tested; the must, when prepared for fermentation, should be tested. The fermenting mixture should from time to time be tested. The new wine should be tested; and in short, in all its stages through the processes of principal fermentation, after-fermentation, cellaring, and preparation for bottling, the wine should be frequently tested, and the results recorded.

But in most cases all this is neglected. Wine-making, instead of being carried on upon scientific principles, is conducted on the old long-established principles of *rule of thumb* and *rule of mouth*; often on no principles at all; and, no doubt, thousands of gallons of bad wine are made yearly, where it would have been quite as easy and as expenseless to make good wine instead of bad.

"I was at dinner one day," says Dr. Druitt, "sitting next to the late Archdeacon —, from the Cape. I asked him the reason of the earthy taste in Cape wine. He said, 'My dear sir, if you ever were at the Cape, and were to see the black fellows and their families in the vineyard at the vintage season, and how they make the wine, you would think *earthy* a very mild term indeed to be applied to it.'"—*Report on Cheap Wines*, p. 91.

In wine-making, as in every other branch of chemical manufacture, science and cleanliness are necessary to insure successful and profitable results.

CONNECTION BETWEEN THE CHEMICAL COMPOSITION OF WINES AND THEIR EXCELLENCE IN QUALITY.

179. In LIEBIG's *Annalen der Chemie*, for 1847, vol. 63, page 384, there is a Memoir, by Professor FRESSENIUS, containing a detailed account of the careful analysis of four first-class Rhine wines, accompanied by some speculations on the connection between the chemical composition and the excellence in quality of wines of that description. As that memoir has been often quoted, and its deductions have been accepted as legitimate by high chemical authorities, though, as it appears to me, without sufficient consideration, I shall ask the reader to compare those deductions with the matters of facts that have been brought out by the experiments described in the present work.

180. The results of Fresenius's Analyses are given in Table XI., page 105. I have calculated them in these forms in order that the results may be comparable with those given in Tables I. and II. of this work.

These four wines had been prepared with the greatest care, from pure grape-juice without addition and by a close fermentation. They were of the vintage of the year 1846, and were analysed in March of 1847, when they were consequently only four months old. The first three wines were clear: the fourth was turbid in consequence of the fermentation being still in action. The residue of the wines, bottled and placed in a cellar, went again into fermentation, and early in the following July they were in a state of effervescence. The wines, therefore, had not completed the after, or secondary fermentation at the time of their analysis.

Fresenius informs us that good judges of the quality of Rhine wines considered these four wines to rise above one another in value in the order in which they are arranged in the Tables, the wine No. 4 being the most esteemed of the series. Coupling this fact with those shown by the figure in the Tables, he draws the following conclusions:—

1. The goodness of a wine is so much the greater—

a, the less it contains of free acid.

b, the more it contains of sugar.

c, the greater its quantity of extract.

2. The quantity of alcohol does not decidedly influence the goodness of a wine.

3. The specific gravity of a wine is no criterion of its goodness.*

Let us examine the validity of these conclusions:—

No. 3 we may safely accept. The facts recorded in Tables I. and

TABLE XI., A.—WEIGHT in GRAINS of the CONSTITUENTS of a CENTIGALLON of FOUR RHINE WINES.

	Wines of the Year 1846. Analysed in March, 1847.	Specific Gravity.	Centigallon of Wine.	Absolute Alcohol.	Total Acidity as $H_2C^2HO_2$.	Sugar.	Solid Residue at $212^{\circ} F.$
1	Hattenheimer . . .	.9959	697.13	74.64	3.88	24.96	29.38
2	Markobrunner . . .	1.0012	700.84	78.08	3.74	31.68	36.29
3	Steinberger . . .	1.0070	704.90	70.96	3.50	31.66	39.19
4	Steinberger Auslese .	1.0323	722.61	73.49	3.06	62.35	76.27

TABLE XI., B.—PER-CENTAGES of the CONSTITUENTS of FOUR RHINE WINES.

	Wines of the Year 1846. Analysed in March, 1847.	Specific Gravity.	Absolute Alcohol by Weight.	Total Acidity as $H_2C^2HO_2$.	Sugar.	Solid Residue at $212^{\circ} F.$
1	Hattenheimer . . .	.9959	10.707	.556	3.580	4.214
2	Markobrunner . . .	1.0012	11.141	.533	4.521	5.178
3	Steinberger . . .	1.0070	10.067	.497	4.491	5.559
4	Steinberger Auslese .	1.0323	10.170	.424	8.628	10.555

II. completely justify it. However, the high specific gravities of Fresenius's wines are due to the great quantity of sugar which they contained.

No. 2 is also a sound conclusion; for, although wines are, within certain limits, powerful and good, in proportion to the quantity of alcohol they contain, yet, when taken alone, the quantity of alcohol affords no indication of the value of the wine. It is *one element* of goodness, but not sufficient in itself to constitute goodness. As a decisive proof of this fact, I may refer to the wine No. 12 in Tables I. and II. This contained 50 per cent. more alcohol than Fresenius's best Steinberger, but it was detestable rubbish, bought of a London grocer for a shilling a bottle, and not worth a penny. Hence, predominant alcohol, considered alone, is no mark of goodness in a wine.

181. I now come to Professor Fresenius's first set of conclusions, to each of which, *a*, *b*, and *c*, I object.

Conclusion 1 *a*. *The goodness of a wine is so much the greater, the less it contains of free acid.* Is that correct?

I think not. In Tables I. and II. I have given many examples of good, sound, pleasant-tasting, wholesome wines—of the light sort—which have 450 grains of acid in a gallon; and I have given other examples of wines that have less than 450 grains of acid in a gallon. Upon comparing these with one another, it does not appear that the latter are better wines than the former, unless some special circumstance, such as predominance of alcohol, acts in their favour. Fresenius's results do not warrant his conclusions; for, although the acid of his four wines diminishes in the order of Nos. 1 to 4, the alcohol also diminishes, though irregularly, in the same order, while the sugar increases. This manifests, that if his new wines were fermented to maturity, their alcohol, and no doubt their acid also, would increase as their sugar diminished, for acetic acid is invariably produced during the fermentation of sugar into alcohol. Wines that are weak in acid are either poor altogether, or they are rich, in alcohol, in sugar, or in some flavouring matter, which compensates for that agreeable sharpness which is given to wine by a due proportion of acid. Taking Fresenius's results in company with those given in Tables I. and II. we find no evidence to prove that great diminution of acid is a desirable quality in wines; but, on the contrary, we have reason to assume that a certain and a pretty large quantity of acid is necessary to the composition of first-rate wines.

Conclusion 1 *b*. *The goodness of a wine is so much the greater the more it contains of sugar.* Is it so?

Certainly not. Professor Fresenius was deceived by the circumstance that his wines contained much sugar, because they were prepared from very ripe grapes, and had not been completely fermented. Good wines of the light sort—and those of the Rhine belong to that

category—should have, and indeed usually have, either no sugar, or very little. See Nos. 40 and 41 in Table I. All the sugar that occurs in the grape juice ought, in the making of Rhine wines, to be entirely fermented into alcohol; and if this is done properly, and no injurious substances are introduced into the wine, by dirtiness or carelessness, and the wine is so well fermented as to have the alcohol in proper proportion to the acid, it will be sweet enough for agreeable drink without containing the least particle of free sugar. If sugar is practically left in wine—if on analysis you find it there—you may take it as a proof of incompleteness of fermentation, or that the manufacturer meant to produce a sweet wine, or that he was conscious of the presence of some improper substance or quality in the wine, which he considered it necessary to cover or hide by sweetness—*mere sweetness*, the lowest, and most easily and cheaply imitated, of all the qualities by which wine is characterized. Consequently, the presence of abundant sugar in wine is no proof of superior goodness.

Conclusion 1 c. *The goodness of a wine is so much the greater, the greater its quantity of extract.* Do we find it so?

No. It is true that Fresenius, in his account of the composition of his four wines, shows that the extract or solid residue increases in amount in the order 1, 2, 3, 4, according to which he says the four wines are esteemed; but it is of importance to remember that these wines were immature, and that the residues, besides containing the free acid and sugar, the incombustible materials, the neutral tartrates, phosphates, sulphates, and chlorides, and the neutral organic bodies which I have figured in column 13 of Table I.; contained also the nitrogenous organic substances which were to furnish the ferment during all the period of the after-fermentation which the wines were to undergo between the age of four months and the period of their completion. Besides the ingredients above mentioned, as contained in the solid extract, I may remark that the drying of the extract at 212° Fahr. is not satisfactory; for between that degree and 230° Fahr. a considerable difference in weight occurs, due to the disengagement of water and acetic acid. Now, if we consider the heterogeneous nature of this extract; its quantity; our ignorance of the nature of much of its materials, and of the manner in which they may collectively or individually influence the pleasantness or the wholesomeness of the wines; it is certainly improper to declare that the mere *quantity* of residue, without reference to its *quality*, is a proof of superior excellence in the wine that contains it.

Farther, we may look at other experimental facts. Column 10 in Table I. represents extracts or solid residues of the same character as those of Professor Fresenius, only more highly dried; and column 13 represents the same extracts deprived, as far as possible by calculation, of acids, sugar, mineral salts, neutral tartrates, and all known

bodies, leaving only neutral organic bodies of unknown nature. If *mere quantity* of Extract, irrespective of *quality*, implied goodness in wine, then the wines in Table I. should be excellent in proportion as the numbers in columns 10 and 13 are high numbers; but most certainly the goodness of these wines were in no such proportion.

These reasons show, that the goodness of wines is neither caused by a small proportion of acid nor by a large proportion of sugar or of extract; and we have previously seen, that it is not decidedly influenced by a preponderance of alcohol.

To what then is the goodness of wines attributable? This question is discussed in the next section.

THE MUTUAL RELATIONS OF THE CONSTITUENTS OF WINES.

183. The principle which more than all others appears to regulate and govern the goodness of wines is that, *the weight of their Alcohol should have a certain relation to that of their Acid*. If this relation is right, other things are comparatively indifferent. If it is wrong, alterations of other constituents do not effectually repair this primary defect.

To illustrate this subject, the facts which are developed in Tables I. and II. shall be put under a new point of view, namely, that in which the quantity of the acid of each wine is taken as *Unity*, or the standard with which the quantities of other constituents are to be compared.

TABLE XII.—CLASSIFICATION of WINES, depending upon the relation borne by WEIGHT of their ACID to that of their ALCOHOL and SUGAR.

No.	CLASS I.—Wines Strong in Alcohol.	Alcohol to 1 Acid.	Sugar to 1 Acid.
1	Old-bottled Port	56.74	9.26
2	Newly-bottled Port	45.87	12.58
3	Public-house Port	56.20	14.29
4	Madeira	28.55	6.76
5	Montilla, 1854	38.29	1.39
6	Ditto, newly bottled	40.43	1.52
7	Oloroso, 1843	37.27	1.58
8	Ditto, newly bottled	39.86	1.58
9	Oxford Sherry	43.65	5.13
10	Public-house Sherry	33.92	5.83
11	Tarragona	33.08	5.13
12	British Port	23.47	11.70
13	British Sherry	31.78	11.49
14	Como	22.47	5.95
	Average of the 14 Wines . .	37.97	6.73
	Average of the first 11 Wines .	41.26	5.91
	Average of Nos. 5 to 8 . . .	38.96	1.52
	Average of Nos. 1 to 3 . . .	52.94	12.04

TABLE XII.—Classification of Wines, &c.—*continued*.

No.	CLASS II.—Sweet Wines.	Alcohol to 1 Acid.	Sugar to 1 Acid.
15	Lachryma Christi	17.05	33.22 °
16	Visanto	10.76	36.97
17	Cyprus	15.96	23.64
28	St. Georger	12.69	28.91
35	Champagne	15.34	20.51
	Average of the 5 Wines . .	14.36	28.65
No.	CLASS III.—Light Wines.	Alcohol to 1 Acid.	Sugar to 1 Acid.
18	Santorin	14.90	.61
19	St. Elie	16.43	.37
20	Thera	25.40	.36
21	Red Keffesia	16.26	.00
22	White Keffesia	21.73	.53
24	Red Mont Hymet	14.99	.00
25	Ditto	19.17	.00
26	White Mont Hymet	21.35	.00
27	White Capri	16.03	.74
29	Ofner	16.04	.46
30	Erlaure	17.20	.00
31	Szamorodny	15.56	.47
32	Dioszegher Bakator	19.72	.73
33	White Diasi	21.36	.79
34	Red Voelslauer	18.98	.53
36	Fronsac	14.95	.52
37	Vin Ordinaire	9.71	.16
38	Paysan's Bordeaux	15.01	.19
39	St. Julien, 1858	15.24	.38
40	Castle I. Hock	10.50	.00
41	Rudesheimer	21.05	.27
	Average of the 21 Wines . .	17.22	.34
	The highest	25.40	.79
	The lowest	9.71	.00

184. In Table XII. the wines described in Tables I. and II. are arranged in THREE CLASSES, namely—

CLASS 1. Wines that are strong in Alcohol.

CLASS 2. Sweet Wines.

CLASS 3. Light Wines.

In comparing the constituents of these wines with one another, the weight of the *acid* is taken as UNITY or *the fixed quantity*, and the alcohol and sugar are compared with the acid, weight against weight.

At the bottom of the list of each class the AVERAGES are written. These averages deserve especial consideration.

The average composition of the Port wines is 53 parts by weight of alcohol to 1 part of acid, and 12 parts of sugar to 1 part of acid.

The average of the first 11 strong wines is 41 of alcohol and 6 of sugar to 1 of acid.

The average of the whole 14 strong wines is 38 of alcohol and 7 of sugar to 1 of acid.

The average of the four dry Sherries is 39 of alcohol and only $1\frac{1}{2}$ of sugar to 1 of acid.

Of the five Sweet Wines, the average is nearly 15 parts of alcohol and 30 parts of sugar to 1 part of acid; but individually they vary considerably; the sugar from $1\frac{1}{2}$ times to $3\frac{1}{2}$ times the weight of the alcohol, and from 20 to nearly 40 times the weight of the acid.

Of the twenty-one Light Wines, the alcohol ranges from 10 to 25 times the weight of the acid, the average being $17\frac{1}{4}$ times. The sugar ranges from *nil* to *eight-tenths* of the weight of the acid, the average being only $\frac{1}{3}$ rd of the weight of the acid.

These numbers, it will be observed, are relative proportions by weight of the alcohol and the sugar to the acid. To bring these into consideration as absolute quantities, we must remember that the quantity of free acid, namely, the total acidity, varies from 250 grains to 500 grains in a gallon. These are the extreme limits, the lower quantities being chiefly confined to the alcoholic wines and the larger quantities to the light wines. By fixing the quantity of acid in a gallon, we can fix also the relative strength in alcohol.

If we venture to draw general conclusions respecting the right constitution of wines from the analysis of these few and miscellaneous examples, we must state them nearly in these terms.

185. A. AS TO LIGHT WINES:—

1. The Light Wines have 450 grains of acid in a gallon, of which about one-fourth part is volatile acid and three-fourth parts are fixed acid.

2. The quantity of absolute alcohol is twenty-one times as much as that of the total acid by weight.

3. There is no sugar.

These conclusions are founded upon the opinion that the acid is the prime regulator of the taste of wines. That opinion seems to be forced

upon us by the inspection of these Tables. With an acidity of 450 grains of acid in a gallon you can have a first-rate wine; but the acid must be covered with from 20 to 25 times, with at least 20 times its weight of alcohol. Twenty-one times seems to be a quantity warranted by the observations made on good commercial wines. As to the sugar, it appears to be a superfluity. The average quantity of it in these 21 light wines is under 150 grains in a gallon; while the acid has a mean weight of 417 grains; and the alcohol a mean weight of above 7,000 grains. The sugar residue seems to be the mark of failure in perfect fermentation. There ought to be none left in the completed wine, and in many first-rate wines there is none.

In Rudesheimer, No. 41, I found sugar to the extent of only $\frac{1}{2}$ per cent., or 118 grains in a gallon; acid to the extent of 440 grains in a gallon; and alcohol to the amount of 21 times the weight of the acid. It was a capital wine, and, though containing a maximum quantity of acid, was not a shade more sour than such a wine ought to be.

If, passing from a first-rate Light Wine, we examine wines of a medium character, such as the Claret, No. 39, and others in the list, we find that to 1 part of acid we have then from 15 to 17 parts of alcohol; while in the commoner acid wines, such as Vin ordinaire, No. 37, and Castle I. Hock, No. 40, we have to 1 part of acid only 9 or 10 parts of alcohol with little or no sugar.

On the other hand, wines of fine quality, such as the superior Rhine wines and French wines, will have alcohol to the extent of from 21 to 25 times the weight of the acid.

Thus, the weight of the acid being fixed, the quality of the wine will depend upon the relative proportions of the alcohol, going by a sort of sliding scale, the degrees of which are 25° best; 20° very good; 15° middling; 10° common; under 10° sour; above 25° *fortified*.

But, observe, in this place, it is necessary to take care not to mix up and confuse the notion which respects the *proper relative proportions* of these constituents of wines with that of their absolute strength. You might have a wine containing 21 parts of alcohol to 1 part of acid, and yet have a weak wine. The strength is fixed by the assumption that the gallon of wine should contain 450 grains of acid. All wines must be judged of from this twofold point of view, namely, the weight of alcohol in a gallon and its proportion against the acid. Of course, I do not propose that all wines should be adjusted to this one standard, or imagine that wines of this standard would suit the taste of all consumers of wine. I merely point out conclusions that seem to be forced upon our consideration when we examine the results of our Wine Testings. We cannot avoid taking notice of this question. *Is not the goodness of wines more dependent upon the RELATION of their ALCOHOL to their FREE ACID, than upon any other consideration whatever?* If this is true, it points to important practical operations in the manufacture of wines.

186. B. AS TO SWEET WINES:—

4. The Sweet Wines seem to offer little in the way of general principle. Taking the acid as unity, their alcohol is about equal to that of light wines of medium quality, and their sugar twice or thrice as heavy as their alcohol. They have special flavours, which result from the character and ripeness of the grapes from which they are made. Each wine of this sort must make a character for itself.

187. C. AS TO STRONG WINES:—

5. The strong wines have very little free acid; partly because a certain strength of alcohol renders the bitartrate of potash insoluble and partly because such wines are prepared by adding to genuine wines large quantities of distilled spirits that are entirely free from acid.

The four sherries Nos. 5 to 8, which contained an average of 39 parts of alcohol and only $1\frac{1}{2}$ part of sugar to 1 part of acid, possessed the quality of *dryness* in a high degree; indeed, in a degree so high, that to my taste the impression was unpleasant. Wines that contain from 15 to 25 parts by weight of alcohol to 1 part of acid I find to be most agreeable; that proportion of alcohol appears to cover the acid sufficiently. With more than 25 parts of alcohol to 1 part of acid, you are beyond the limits of natural wine, and have a mixture brought artificially up to a standard which many men may no doubt approve of, after being educated to do so, but which cannot be universally agreeable. I imagine that, if the port wines Nos. 1 to 3, which contained an average of 53 parts of alcohol to 1 part of acid—or twice the proportion proper to good natural wine—could be prepared like these sherries free from sugar, they would scarcely be drinkable. The residuc of sugar in these strong wines is necessary to render them palatable in the presence of such superabundant fiery alcohol. In all mixed spirits that are strong in alcohol, large doses of sugar are required. Rum-punch, whisky-toddy, brandy-and-water, and gin-and-water, are only drinkable when strongly sweetened.

188. D. AS TO EXTRACTIVE MATTERS.

The experimental determination of the quantities of the ash, the alkali, and the solid residue of wines, is much more troublesome, and takes up much more time than the testing of the alcohol, the acid and the sugar; and yet in the present state of chemical knowledge of wine-testing—that is to say, as far as I am versed in it—the products of analytical investigations are less interesting, less comprehensible, and less capable of useful applications than is the knowledge gained by testing for alcohol, acid, and sugar. The testing of the extractive substances is too much like travelling on so many roads that lead nowhere. We gather together a great quantity of facts, but cannot see any good use to make of them. No doubt this arises in a great degree from the circumstance that the analysis is not carried far enough. The ash should be more completely analysed. In particular the quan-

tity of phosphates contained in it ought to be determined, and possibly the separate quantities of potash, soda, lime, magnesia, iron, and other mineral constituents. Above all, the neutral organic bodies, which in some cases enter so largely into the composition of wines, should be investigated, and if possible separated and estimated individually. But I fear that, if, in a book like this, which is intended for the use, not of professional chemists, but of wine-merchants, wine-makers, and other practical men, I were to go into details on all these points, even supposing detailed instructions to be possible, I should frighten most readers from the really practical parts of the inquiry. I have contented myself, therefore, with describing Testing Processes which every one can follow, and I have abstained from entering upon analytical processes, which would demand for successful results the knowledge and leisure of professional chemists.

CHEMICAL NOTES ON SOME PARTICULAR POINTS IN THE MANUFACTURE OF WINES.

190. In the last section I have laid down the principle that a *good light wine* should, on the completion of its fermentation, contain, with a given weight of acid, or with a degree of acidity corresponding to a given weight of tartaric acid, as much absolute alcohol by weight as is equal to from 10 to 25 times the weight of the acid; the goodness, agreeableness as drink, and saleability, of the wine rising then from 10 to 25, according to the increase in the weight of alcohol; the best varieties of commercial wine ranging actually from 18 to 22, some good kinds falling as low as 15, and first-rate rare wines rising up to 25.

This rule as to *quality*; then, as to *strength*, I have pointed out a method of registering it by fixing upon a given weight of acid in a gallon of wine as a standard of comparison.

As to *Fancy Wines*, such as wines that are sweetened with sugar, or fortified with spirit, or saturated with carbonic acid; these must always be so various as to be beyond the reach of general rules.

Supposing the principle that is thus applied to light wines to be correct, it follows that it is of importance to the manufacturer of wines to take such measures with his MUST, or GRAPE JUICE, that, when it is fermented, it shall produce the wine that he wishes to have, both as regards its *strength* and its *quality*. That is to say, he must take care that the acid is in sufficient quantity, and in no more than sufficient quantity, for the volume of liquor that is operated upon; and he must also take care that the sugar in the mixture is in sufficient quantity to produce the alcohol that is requisite to *cover the acid* to any degree that may be determined upon.

He must therefore commence his process of wine-making by Testing his Must both for sugar and for acid.

COMPOSITION OF MUST.

191. Generally speaking, Must is examined only as to its *density*, and that is done by means of a hydrometer, see Fig. 5, which, from this application of it, and from the scale which is most frequently applied to it, is called a *Saccharometer*. Table XIII. fully explains the indications of this instrument.

TABLE XIII. — SACCHAROMETER TABLE according to BALLING.
Handwörterbuch der Chemie (1859), Band vii., S. 4.

COLUMN 1 indicates the per-centage of cane sugar contained in any aqueous solution of cane sugar submitted to trial, being the number marked on the scale of Balling's Saccharometer.

COLUMN 2 shows the corresponding specific gravity of the solution of cane sugar according to Balling, the temperature being $63\frac{1}{2}^{\circ}$ Fahr., and water being taken as = 1.0000.

Other sugars than cane sugar differ a little in the specific gravities of their per-centage solutions.

1	2	1	2	1	2
Per Centage.	Specific Gravity.	Per Centage.	Specific Gravity.	Per Centage.	Specific Gravity.
1	1.0040	26	1.1106	51	1.2385
2	1.0080	27	1.1153	52	1.2441
3	1.0120	28	1.1200	53	1.2497
4	1.0160	29	1.1247	54	1.2553
5	1.0200	30	1.1295	55	1.2610
6	1.0240	31	1.1343	56	1.2667
7	1.0281	32	1.1391	57	1.2725
8	1.0322	33	1.1440	58	1.2783
9	1.0363	34	1.1490	59	1.2841
10	1.0404	35	1.1540	60	1.2900
11	1.0446	36	1.1590	61	1.2959
12	1.0488	37	1.1641	62	1.3019
13	1.0530	38	1.1692	63	1.3079
14	1.0572	39	1.1743	64	1.3139
15	1.0614	40	1.1794	65	1.3190
16	1.0657	41	1.1846	66	1.3260
17	1.0700	42	1.1898	67	1.3321
18	1.0744	43	1.1951	68	1.3383
19	1.0788	44	1.2004	69	1.3445
20	1.0832	45	1.2057	70	1.3507
21	1.0877	46	1.2111	71	1.3570
22	1.0922	47	1.2165	72	1.3633
23	1.0967	48	1.2219	73	1.3696
24	1.1013	49	1.2274	74	1.3760
25	1.1059	50	1.2329	75	1.3824
1	2	1	2	1	2

To show the range of densities which occur in practice, I quote a speech made by an eminent wine-grower in Australia, at an annual meeting of the "*Hunter River Vineyard Association*." I take it from a Report which was kindly sent to me by WM. KEENE, Esq., the President of that Association. The densities referred to by Mr. WYNDHAM, the speaker in question, are the degrees of the Saccharometer described above; that is to say, Mr. Wyndham considers that a Must which indicates 30° on the saccharometer indicates 30 per cent. of sugar, and so on.

Mr. WYNDHAM then said it might be interesting to some of them to know the amounts of sugar in must obtained since 1857, at Dalwood. They used this saccharometer to ascertain, and it told exactly the per-centage of sugar in the must that they were to make wine of. In 1858, they would recollect that the vintage was a very fine one; the per-centage of sugar in the must was at the lowest 24, and at the highest 27; it ranged from 25 to 26. In 1859, when they had the grapes nearly cleared off by caterpillars, it ranged from 22 to 27. In 1860 their first must gave 22 to 23 and 25; the chief quantity was 24; then followed some heavy rains, and some of the must from the grapes cut after the rain was as low as 19, but this produced a nice palatable light wine; 24, 25, and 26 was the very best per-centage of sugar they could have in the must. In 1861 they had fearful rains, and some of the must was as low as 15, 16, and 17; this, with great care, made a palatable but poor wine; it was sound even to this day, and though not well flavoured it was pure—it was never labelled "Dalwood." During 1861, when the weather cleared up, they got a fair quantity containing 18 and 20 per cent. In 1862 the season was favourable, but the musts were not high—some containing only 21 per cent., but the grapes had a beautiful even ripeness—in that respect they that year attained the height of perfection; he meant even ripeness of the whole bunch; the must of their Black Verdôt, in 1862, contained 24 per cent. Their best whites, which received prizes, were of must containing 24 per cent. sugar. In 1863 they had had beautiful weather at the beginning of the vintage, the musts stood at 23 and 24—some as high as 32, which produced magnificent wine; the rains then came on, and the musts were only 18, 19, and 20; they however made a good wine with great care. In 1864 they again had fearful rains, and the musts showed only 19 to 20 in the best lots—some were as low as 15 to 18, yet made sound wines. A small quantity stood at 21. In 1865 the musts ranged between 22 and 26 at Dalwood. At Bukkulla they had musts averaging 41. In 1860, at the same place, they had musts that stood as high as 60. In 1863 the amount of saccharine matter in the Bukkulla musts was from 38 to 40 something. In 1864 there was a little drop as low as 24, and others as high as 38. In 1865 the lowest was 38, and much was as high as 45. The wines made from this had more point. Bukkulla 1863-4-5, had yet to go before the public—they purposed keeping them in the nursery, to give them age so long as the purse would hold out.—From the *Maitland* (Australian) *Mercury*, of 6th May, 1865.

The assumption that degrees of the Saccharometer shown by grape juice are equal, as indicators of sugar, to degrees shown by solutions of pure sugar in water, is erroneous; because, in grape juice there is, in addition to sugar, all the acids, salts, ferments, and neutral bodies, which go to form the constituents of wine, and all of which act upon the saccharometer, and render it fallacious as a mere indicator of sugar. The following Table, published by Professor FEHLING, shows that these fallacies are too important to be neglected.

TABLE XIV.—PER-CENTAGES of SUGAR found by Experiment in GRAPE JUICE of different SPECIFIC GRAVITIES.—FEHLING, *Handwörterbuch der Chemie*, ix., 676. Published in 1864.

Specific Gravity.	Sugar per Cent.	Specific Gravity.	Sugar per Cent.	Specific Gravity.	Sugar per Cent.	Specific Gravity.	Sugar per Cent.
1.059	12.0	1.074	15.6	1.083	18.2	1.090	24.6
1.062	12.5	1.074	15.9	1.084	18.5	1.090	26.7
1.062	12.8	1.075	16.8	1.085	17.2	1.091	18.6
1.054	13.4	1.075	17.0	1.085	18.4	1.091	19.6
1.064	14.0	1.076	16.0	1.085	18.7	1.091	20.4
1.065	13.9	1.077	17.2	1.085	20.4	1.092	19.2
1.066	14.5	1.078	15.5	1.086	17.8	1.093	20.4
1.068	14.2	1.079	14.9	1.086	19.8	1.094	19.6
1.069	14.7	1.079	16.3	1.086	20.0	1.095	21.3
1.069	15.0	1.079	20.2	1.087	17.8	1.095	27.0
1.069	15.8	1.080	17.5	1.088	17.1	1.095	28.1
1.070	14.4	1.081	17.6	1.088	19.6	1.096	21.3
1.072	16.3	1.083	16.6	1.089	18.2	1.096	26.7
1.073	16.5	1.083	17.1	1.089	23.2	1.097	24.7
1	2	1	2	1	2	1	2

CHEMICAL TESTING OF GRAPE JUICE FOR SUGAR.

192. The necessity of learning the exact composition of grape juice before setting it to ferment, and the impossibility of doing it by means of the saccharometer, points to the necessity of employing the chemical method. By this means the quantity of sugar can be determined with readiness and exactness. The process is fully described between pages 76 and 83 in this work. The grape juice to be operated upon should be diluted with water from 1 volume to 10 volumes and be decolourized.

The specific gravity of the grape juice can be determined exactly by weighing it in the bottle described at page 16.

The sugar of the grape juice and currant juice, Nos. 46, 47, in Tables I. and II., were estimated on this plan.

CHEMICAL TESTING OF GRAPE JUICE FOR ACID.

193. The acid in grape juice is a mixture of acids, principally tartaric and malic acids. There is no volatile acid present. If you distil it, as described at page 71, no acid goes over. The total acidity should be estimated as tartaric acid, as is recommended for the total acidity of wines. The process of testing is precisely the same as that used for the testing of acid in wines, and which is fully described at § 118, page 68.

The quantity of grape juice to be operated upon is 10 septems. The results of the testing are calculated in the manner described in § 123, page 70. The range of free acid in Must is from 0.3 to 1.5 per cent. In good seasons it rarely goes beyond 0.7 per cent.

By the foregoing two operations you determine, with short reckonings, how many grains of sugar and of acid you have in a gallon of the Must. You take notes of these results, in order to be able to compare them afterwards with the testings of the wine in its different stages of manufacture, and when it is in its final complete state, fit for sale or for consumption. From these notes also you are to calculate the additions that are in bad seasons necessary to be made to the Must, to correct it for deficiency of sugar and for superfluity of acid.

CONVERSION OF SUGAR INTO ALCOHOL BY THE OPERATION OF FERMENTATION.

194. The kind of sugar that is present in grape juice—grape sugar—is that which is described at page 77 as Anhydrous Grape Sugar, agreeing with the formula CH_2O , and having 30 as its atomic weight. When this sugar undergoes fermentation, it is converted into alcohol and carbonic acid, the decomposition taking place in the following proportions:—

$$\left. \begin{array}{l} \text{CH}_2\text{O} = 30 \\ \text{CH}_2\text{O} = 30 \\ \text{CH}_2\text{O} = 30 \\ \hline \text{together} = 90 \end{array} \right\} \text{produce} \left\{ \begin{array}{l} \text{H, C}^2\text{H}^5\text{O} = 46 \\ \text{CO}^2 = 44 \\ \hline \text{together} = 90 \end{array} \right.$$

That is to say, 90 parts by weight of grape sugar produce 44 parts by weight of carbonic acid, which escapes as gas, and 46 parts by weight of absolute alcohol, which remains in the liquor. Then, 100 parts of sugar will produce 51.111 parts of alcohol, since

$$90 : 46 = 100 : 51.111.$$

This is the *theoretical* process; but, in practice, PASTEUR declares that there is a loss of between 4 and 5 per cent. of sugar, which is converted during the fermentation into glycerine, succinic acid, and carbonic acid; the glycerine being the chief product. And PASTEUR thinks that the glycerine and succinic acid thus formed have a sensible influence on the taste of wines.

Admitting this loss of $4\frac{1}{2}$ per cent. of sugar, we must calculate the produce of the fermentation as follows:—

$$100 : 51.111 = 95.5 : 48.81$$

That is to say, 100 parts of grape sugar produce 48.81 parts of alcohol; or, to put the figures into a convenient form for use, we say:—

195. To find the weight of Alcohol produced by a given weight of

Anhydrous Grape Sugar.—Multiply the weight of the sugar by $\cdot 4881$. The product is the weight of the alcohol.

196. *To find the weight of Anhydrous Grape Sugar required to produce a given weight of Alcohol.*—Multiply the weight of the alcohol by $2\cdot 0487$ (or shortly $2\cdot 05$). The product is the weight of the sugar required.

If hydrated or crystalline grape sugar is used, the reacting quantities are different. That substance contains $\frac{1}{11}$ th part of its weight of water, see § 138, page 77. Consequently, when 10 parts of the anhydrous sugar are required, 11 parts of the hydrate must be taken; and the foregoing problems must be altered as follows:—

197. *To find the weight of Alcohol produced by a given weight of Hydrated Grape Sugar.*—Multiply the weight of the sugar by $\cdot 44373$. The product is the weight of the alcohol.

198. *To find the weight of Hydrated Grape Sugar required to produce a given weight of Alcohol.*—Multiply the weight of the alcohol by $2\cdot 25357$. The product is the weight of the sugar required.

If cane sugar is used, the quantity must be calculated in accordance with the formula given in § 139, page 77, still continuing to allow for a loss of $4\frac{1}{2}$ per cent. This calculation yields the following problems:—

199. *To find the weight of Alcohol produced by a given weight of Crystallised Cane Sugar.*—Multiply the weight of the sugar by $\cdot 5138$. The product is the weight of the alcohol.

200. *To find the weight of Crystallised Cane Sugar required to produce a given weight of alcohol.*—Multiply the weight of the alcohol by $1\cdot 9453$. The product is the weight of the sugar required.

CONVERSION OF ALCOHOL INTO ACETIC ACID BY A PROCESS OF FERMENTATION.

201. The following diagram shows the conversion of Alcohol into Acetic Acid by combination with Oxygen:—



That is to say, one atom of Alcohol = $\text{H}, \text{C}^2\text{H}^5\text{O}$, and two atoms of Oxygen are together equal to, and resolvable into, one atom of Hydrated Acetic Acid = $\text{H}, \text{C}^2\text{H}^3\text{O}^2$ and one atom of water. There is, however, in practice a little waste of alcohol, evidenced by the disengagement of some carbonic acid gas = CO^2 , and therefore I shall suppose that 48 instead of 46 parts of alcohol produce 60 parts of acetic acid. These relative quantities afford the following simple methods of calculation:—

a. To find the Weight of Acetic Acid produced by a given Weight of

Alcohol.—Multiply the Alcohol by 1·25. The product is the weight of the Acetic Acid.

b. To find the Weight of the Alcohol which produces a given Weight of Acetic Acid.—Multiply the Acetic Acid by ·8. The product is the weight of the Alcohol.

No wine exists free from acetic acid. Its production seems to commence at the very beginning of every fermentation. It is apparently an unavoidable constituent of wines; and possibly one that is useful and necessary. With alcohol, it forms the volatile and odorous acetic ether, which seems to form part of the aroma of every wine.

The average free volatile acid of the 19 wines enumerated at page 73, is 100 grains in a gallon. Reckoning this to be acetic acid, it would, according to the above formula, take 80 grains of alcohol per gallon to yield it. Consequently, in providing sugar to produce in wine a given weight of alcohol per gallon, this average source of loss of alcohol—80 grains per gallon—should be provided for.

LOSS AND GAIN OF ACID BY MUST DURING FERMENTATION.

202. According to Berthelot, there is a great diminution in the acid of Must during the first few days of the vinous fermentation; the acid destroyed being chiefly malic acid, not tartaric. He gives the following examples [which I have expressed according to the system used in this book as grains in a centigallon]. The acidity is valued as if tartaric acid:—

1. Original acidity	7·00 grains.
Acidity after 15 days' fermentation . .	4·06
Loss	2·96
2. Original acidity	7·07 grains.
Acidity after 6 days' fermentation . .	5·67
Loss	1·4
3. Original acidity	6·09 grains.
Acidity after 7 days' fermentation . .	2·94
Acidity after 4 months' fermentation . .	4·41
Loss	1·68

I do not find statements of such losses of acid in any other work. But indeed the matter, though important, is one to which wine-makers seem to have hitherto paid no attention.

Against this diminution of acidity, we have to reckon the increase of acidity due to the slight introduction of succinic acid, and to the constant and sometimes large production of acetic acid.

It is desirable that wine-makers should not only test the acidity of their Must, but, from time to time, test also that of the fermenting wine, in order to guard against the increase of acetic acid. It is also of great importance that the experiments of Berthelot on the great destruction of acid during the early stages of fermentation should be proved or disproved; for while this is an uncertain point, no wine-maker can judge from the acidity of his Must what will be the resulting acidity of his matured Wine. The statement that a loss of acid occurs, which ranges from 20 to 40 per cent. of the original quantity, is too important to be left unexamined.

TREATMENT OF MUST IN BAD SEASONS. MANUFACTURE OF GOOD WINE FROM SOUR GRAPES.

203. In cold seasons grapes do not become sufficiently ripe to make good wine. The expressed juice contains too little sugar and too much acid. For example, it may be found to contain 12 or 14 per cent. of sugar, and from 1000 to 1200 grains of acid per gallon. If submitted in that condition to fermentation, the wine will be undrinkably sour. Speculative science steps in here to remedy these defects.

In a good season the Must possesses about 20 per cent. of sugar, and from 350 to 500 grains of acid in the gallon.

The scientific correction of the sour Must of bad seasons consists in increasing the sugar and diminishing the acid, till both agree with the proportions contained in the Must of good seasons.

The method of proceeding is as follows:—

The Must is tested for sugar and for acid, by the processes referred to in § 192 and 193. It is then diluted with water till the acid is reduced to the proper quantity of grains in a gallon. Sugar is then added, in sufficient quantity to produce enough alcohol to properly cover the acid. See § 183. That is the theory of the operation. It might be expected that this great dilution of the Must would enfeeble the bouquet of the wine; but Dr. LOUIS GALL, who invented the process, and Dr. MOHR, who describes it in the *Handwörterbuch der Chemie*, B. ix. p. 615, both declare that everybody was astonished to find that no *diminution of bouquet* took place. The first obstacle to the success of the operation was the use of impure starch sugar, which contained dextrine. This caused a quantity of unfermented matter to remain in the wine, giving it a tendency to decay, and rendering it unpleasant to drink. When pure starch sugar was used, this difficulty vanished, and the wine that was produced became rapidly transparent, was very durable, possessed an excellent flavour, and retained the bouquet common to wine of the same character, the Must of which had not experienced dilution.

The reduction of this method of wine-making to practical operations is as follows:—

204. CORRECTION FOR ACID.—The Must, having been tested for sugar and acid, is diluted, as I have stated above, to the desired extent. What that dilution should be, is not a point to be fixed by the chemist, but to be determined by the knowledge and experience of the practical wine-maker. First of all he must fix upon the quantity of acid that he desires to retain in the completed wine, and then he has to find what allowance is to be made for the gain and loss of acid during fermentation, as described by Berthelot and Pasteur. See § 202. There is a great want of records of experience in this matter. Supposing you desire to have 450 grains of acid in a gallon of completed wine, the question is, how much acid should be left in the Must, 450 grains, or 100 grains less or 100 more? That is clearly a point to be settled by experience. The same rule will probably not hold good for wines of all kinds, nor for wines of the same kind, when the grapes are of different degrees of ripeness, or when the fermentation is to be effected at different degrees of temperature.

In Table XV., page 124, I have given the equivalent measures of liquor that correspond to different degrees of acidity. This will assist the operator in making dilutions, &c. Suppose a Must to be found to have 1200 grains of acid in a gallon, and that it is considered desirable to reduce the acidity to 450 grains in a gallon. Then the corresponding volumes will be found in column 2 of this Table. 83·3 volumes of the strongly-acid Must is to be diluted to 222 volumes, to form the weak acid. Special measures are to be ascertained by a rule-of-three sum. Thus, (a) 50 gallons of the strong liquor require dilution. Then—

$$83\cdot3 : 222\cdot0 = 50 : 133\cdot3$$

(b) 200 gallons of the diluted liquor are required—

$$222 : 83\cdot3 = 200 : 75\cdot045$$

In case (a), 50 gallons are to be diluted to $133\frac{1}{3}$ gallons. In case (b), 75 gallons are to be diluted to 200 gallons.

205. CORRECTION FOR SUGAR.—The wine-maker having decided upon the degree of acidity to be given to his Must, has next to determine upon the dosage of sugar. This depends upon what he wishes to be the alcoholic strength of his completed wine. Does he desire the weight of alcohol in his wine to be 15, or 20, or 25 times that of the acid? Here, again, practice and experience must be taken into consultation. He ought to know what is the fermenting power of his Must. Will it ferment enough sugar to produce the 25 degrees of alcohol, or will it stop work when 15 degrees have been produced, and leave a mass of unfermented sugar in the mixture, producing sweet wine when dry wine was wanted? Most probably, grapes of

TABLE XV.—EQUIVALENT MEASURES of LIQUOR corresponding to different Degrees of ACIDITY.

1 Grains of Free Acid in a Gallon.	2 Equivalent Measure.	1 Grains of Free Acid in a Gallon.	2 Equivalent Measure.
100	1000.	1000	100.
200	500.	1100	90.9
300	333.	1200	83.3
350	286.	1300	76.9
400	250.	1400	71.4
450	222.	1500	66.7
500	200.	1600	62.5
550	182.	1700	58.8
600	167.	1800	55.6
700	143.	1900	52.6
800	125.	2000	50.
900	111.	2100	47.6
1	2	1	2

To find the Equivalent Measure.—Divide 100000 by the Number of Grains of Free Acid.

different qualities and of different degrees of ripeness will yield Must differing in fermenting power; and this, therefore, is a subject that calls for skill, knowledge, and judgment on the part of the wine-maker.

But, supposing this difficulty to be overcome, and that the wine-maker desires his wine to contain 20 times as much alcohol as acid. The acid is assumed to be 450 grains in a gallon (variable according to the circumstances above detailed). The quantity of sugar required is then to be calculated according to the principles laid down at pages 119 and 120. Suppose the quantity of Must to be 200 gallons, the weight of alcohol is to be 20 times 450 grains = 9000 grains in a gallon, and this weight multiplied by 200 gives a total of 1800000 grains of alcohol. I shall assume that the sugar to produce this is the hydrated grape sugar spoken of in section 194. Then, in section 198, we have a formula for reducing the weight of the alcohol to the required weight of this crystalline grape sugar:—

$$1800000 \times 2.25357 = 4056426 \text{ grains.}$$

This product, divided by 7000, gives $579\frac{1}{2}$ lbs. as the quantity of sugar required for 200 gallons of the Must in question.

But from this quantity must be deducted the quantity of sugar contained originally in the Must. I have assumed that the Must has been diluted from 75 gallons to 200. I will assume farther that the 75 gallons of strong acid Must contained 14 per cent. of sugar. This, by Table XIII., agrees with the specific gravity of 1.0572. That specific gravity signifies a solution weighing 10.572 lbs. per gallon. We multiply this number by 75, producing 792.9, and we make this calculation:—

$$100 : 14 = 792.9 : x.$$

$$x = 111 \text{ lbs.}$$

Then we deduct from $579\frac{1}{2}$ lbs. the total quantity of sugar demanded for the 200 gallons of diluted Must, the 111 lbs. of sugar already contained in the original 75 gallons of natural Must, and we find $468\frac{1}{2}$ lbs. of sugar to be the quantity required to produce 200 gallons of wine containing 9000 grains of alcohol in the gallon.

To the quantity of sugar thus ascertained, it is necessary to add as much as will compensate for the loss of alcohol which is occasioned by the partial conversion of alcohol into acetic acid as described in § 201.

Sugar and Ferment can exist together in wine without decomposition at certain temperatures corresponding with particular per-centages of alcohol. For example, fermentation ceases in wines when the temperature of the cellar is 50° Fahr. and the wine contains $10\frac{1}{2}$ to 11 per cent. by weight of alcohol. Such a wine transferred to a warmer place begins again to ferment. Hence, in cellars of a higher temperature, wine continues to ferment until the alcohol rises to 13 per cent. by weight, which per-centage approximates so nearly to the limit of strength of natural wines, that a higher degree of strength is an indication that the wine has been fortified with spirits.

MANUFACTURE OF WINE WITHOUT GRAPE JUICE.

205. The fact stated in the preceding section, that a large dilution of Must with water does not deprive it of the power of producing wine that possesses a good bouquet, was first explained by a discovery made by M. PÉRIOT, a wine-grower of Chamirey, in Burgundy. The nature of this discovery will best appear in the details given to reduce it to a practical operation, which appears to have been found successful.

The grapes pressed between wooden rollers and freed from the stalks, are passed into an upright vat which has a false bottom, and a stop-cock and outlet-pipe between the true and false bottom. The Must is allowed to flow out while very little pressure is made upon the mass. The Must so collected is treated in the manner described above.

To the grapes left in the vat, cold water is added to the volume of the Must previously drawn away. The grapes are covered and allowed to soak in the water for two days, being frequently stirred. The water dissolves various soluble materials in the mark or grape-skins, including the substances which give to wines their special taste and odour, and which it appears adhere strongly to the grape mark. At the end of two days the liquor is withdrawn and tested for sugar and acid. It usually contains but 2 or 3 per cent. of sugar, and must have 17 or 18 per cent. added to it. Usually also it is deficient in acid, and must have as much tartaric acid in substance dissolved in it as testing shows to be needful. It is then set to ferment.

A third quantity of wine is made in the same manner; but in this case, the water must digest with the mark from 4 to 6 days. When it is withdrawn, it must be tested like the other liquors, and have the necessary quantity of sugar and acid added to it; sugar to the extent of 20 per cent., or, if the operator thinks proper, to the extent of only 14 or 16 per cent., in order to form a weaker description of wine.

The essence of this procedure lies in the observation, that the mark, separated from the natural grape-juice, retains much of the material which seems to produce the flavour and aroma of wine; that this material is soluble in water; and if extracted and fermented with sugar and pure tartaric acid, it produces wine of excellent quality. According, indeed, to the discoverer, the first wine that succeeds the true juice is preferable to the wine which the true juice produces; the advantage being probably due to the diminution of the quantity of free acid.

These imitation wines have a darker colour than the natural wine, in consequence of the quantity of tannin that is extracted from the grape skins during their prolonged digestion in water.

It is to be hoped that these novel procedures in the art of wine-making will succeed with other manufacturers as they seem to have done with the discoverers. By the two processes jointly, good drinkable wine may be made in all seasons wherever grapes grow. In a good season, natural wine and wine after Pétiot's plan may be made. In a bad season, when the grapes do not ripen, the schemes both of Gall and Pétiot may be made available. Whether, under all circumstances, the grapes contain sufficient fermentable matter to decompose the requisite quantity of sugar, and their skins sufficient aromatic matter to give flavour and aroma to such large quantities of imitation wine, are matters to be settled by future experience.

QUICK PROCESS FOR MATURING WINES.

207. According to M. PASTEUR, the eminent French chemist, most of the diseases of wines, among which he names *acetification*, *ropiness*, *bitterness*, and *decomposition* (*la pousse*), are due to the development

and growth of different varieties of ferments, consisting of minute vegetable cells, which always exist in wines, and under special circumstances of slight changes of temperature, access of oxygen, &c., suddenly become active and destructive. The high price of wines, especially of good wines, is mainly attributable to the destruction caused by these almost invisible plants.

M. PASTEUR finds that the best way to treat these troublesome objects is to KILL them, and this he accomplishes by exposing the wines in closed vessels to a moderately high temperature. After that, these vegetable cells lose their powers of mischief, while the process itself greatly improves the wines and gives them some of the properties of old age. That is the general idea of this new procedure. The details are published in the *Comptes Rendus* of the French Academy of Science, of the dates of May 1st and 29th, and August 14th, 1865. From which papers I give the following particulars.

The bottles are to be filled quite full, and closely corked, without leaving any air in them. The cork is to be tied in with a small cord, but in such a manner that when the wine is heated, and therefore expanded, it shall have power to *lift the cork a little* so as to acquire space, but not be able to drive the cork out, nor even lift it so far as to permit any wine to ooze out between the cork and the bottle. The bottles so filled and corked are placed, cork uppermost, in a stove or hot-house, which is heated to [in his first paper he says from 140° to 212° ; but in his last he says that his latest experiments permit him to hope that the maximum of the desired temperature may be lowered to 113° Fahr., but not under. This circumstance is worthy of notice, because such a temperature may be obtained without the cost of fuel, by using a double glass-house exposed to the natural heat of the sun]. In this temperature the bottles remain for an hour or two. The bottles are then withdrawn, and as each cools, the cork is driven in, the string is cut and removed, and when the bottle is cold, the cork is driven fully in and waxed, which completes the operation. In a stove of proper dimensions thousands of bottles can be heated at once and at little expense. There need be no losses. The cord does not break, nor the bottle burst, during the process.

Nobody would follow this process, or think of recommending it, if it did any harm to the quality of the wine; but, so far from any mischief occurring, quite the contrary takes place. The wine has more bouquet, greater freshness in taste, and even a more beautiful colour, than it had before it was heated. It loses no force, but becomes more robust, for after undergoing the heating, it may be exposed to the air in an open bottle without suffering deterioration. The process is applicable to all wines, white or red, strong or delicate, new wines or aged wines. It qualifies wines of all kinds to suffer export without spoiling. In short, the problem of the indefinite preservation of wines is solved satisfactorily

and completely. It remains for wine-producers to turn to profitable account the results given by science.

Such is M. PASTEUR's account of the Art of converting New Wines into Old Wines in two hours.

HOME-MADE WINES.

208. The juice of fruits from which household wines are made in England—currants, gooseberries, raspberries, pears, apples, &c.—are, perhaps, rarely submitted to scientific treatment. Ripe or unripe, the fruit is pressed, the juice is fermented, the wine is made, sweet or sour as the season permits; excepting that, to cover possible defects, sugar and brandy are added to the wines, in such quantities as commonly suffice to render the wines unwholesome. The juice of some acid fruits often contains from 1500 to 2100 grains of acid in a gallon, and only from 5 to 10 per cent. of sugar. See an example of this in Red Currant Juice, No. 47, in Tables I. and II. To remedy these proportions, the Must ought to be tested for both of these essential ingredients; the acid should be reduced by dilution to 400 or 500 grains in a gallon, and the sugar be increased to 20 or 25 per cent. before fermentation. In very warm seasons, the juice of pears contains too little acid in proportion to its per-centage of sugar, and it then produces a beverage that is too flat for pleasant drink. To prevent this result, the quantity of both ingredients contained in the juice should be tested, and tartaric acid should be added in sufficient quantity to bring the mixture to a right standard. It is a shame that English field-labourers should have to drink the watery fluids commonly called cider and perry, when a little knowledge and care on the part of the farmers would, at a trifling additional cost for sugar and tartaric acid, enable them to brew drinks wholesome and agreeable.

PRESERVATION OF WINES IN PARTLY-EMPTY CASKS.

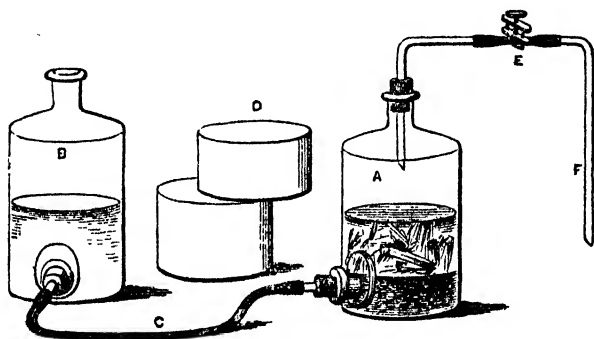
209. If a bottle of light wine is opened, and some of the wine is left for two or three days in the partly-empty bottle, the oxygen of the air acts upon the acetic ferment and the wine becomes sour.

When wine is cellared in a cask, evaporation constantly takes place through the pores of the wood, and air enters by the same passages into the cask to fill the vacuum produced by the evaporation. Unless this air is frequently expelled by the addition of fresh wine, all the wine in the cask is liable to turn sour.

In places where draught wine is used, and where air must be permitted to enter into a cask in proportion as wine is drawn from the tap, the same difficulty occurs; and if the wine is consumed slowly, the oxygen and the acetic ferment frequently turn it into acetic acid.

It is probable that this acetification of wines in partly-empty casks could be prevented by keeping within the casks a constant pressure of

carbonic acid gas, which gas would keep the acetic ferment out of the reach of free oxygen, without which element the acetification cannot occur; for, as I have shown in § 201, the conversion of alcohol into acetic acid demands a large supply of free oxygen. As it may be useful to wine-merchants, who happen not to be familiar with chemical manipulation, to know by what contrivances this constant pressure of carbonic acid gas can be insured, I shall describe two or three sets of apparatus that are employed by chemists for that purpose. Although none of these instruments were constructed expressly for the use now under discussion, they will serve to explain the *principle* upon which they are all founded.

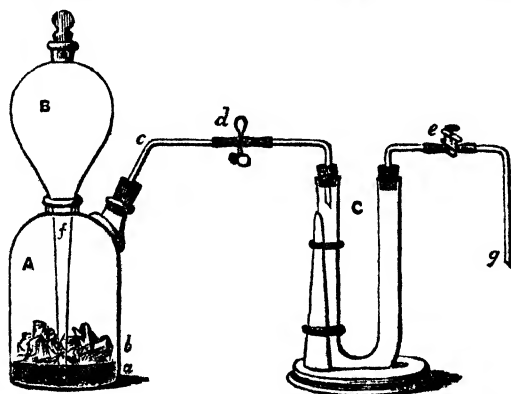


28.

210. The two bottles A, B, in Fig. 28, may be of the capacity of a quart, or any other convenient size: the bottle A is filled to above the tubulure with small siliceous pebbles or sea gravel. Above that bed is placed a quantity of bits of marble, as large as can be conveniently put through the neck of the bottle, and with these the bottle may be nearly filled. The bottles A and B are connected by a vulcanized caoutchouc tube C. The bottle B is nearly filled with diluted hydrochloric acid of commerce. When the bottle A is placed upon the wooden blocks D, above the level of the acid in the bottle B, the acid in A descends into B, and action ceases. When the bottle B is placed on the blocks, and the bottle A on the table, the acid descends into the bottle A, rises up through the flints, acts upon the marble, and disengages carbonic acid gas. But the discharge of this gas is regulated by the clamp E, which acts upon a caoutchouc tube, and can permit any regulated current of gas to pass through, or can stop it entirely when necessary. When the clamp is screwed up, no gas can escape. In that case, the pressure of the gas in the bottle A drives the acid back into the bottle B. As soon as the acid is depressed to the flints, it ceases to act on

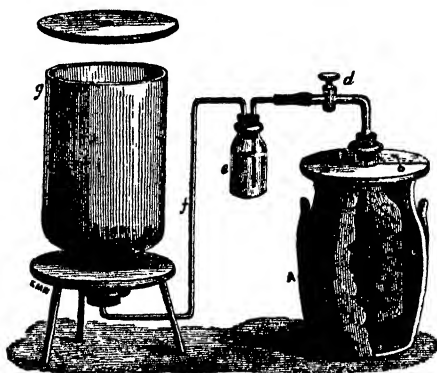
the marble, and the whole is at rest. When the clamp is opened, or partially opened, the gas is pressed out of the bottle A by the acid in the bottle B; the acid then rises in the bottle A, and produces a fresh supply of carbonic acid gas. The force of the current of gas is regulated by the extent to which the clamp is opened, by the strength of the acid that is used, and by the height to which the bottle B is elevated above the bottle A, all of which points are under the control of the operator.

211. The application of this gas generator to a wine cask is effected by means of the tube F, which is passed air-tight into the cask, or is connected by a caoutchouc tube with any tube of glass or metal that is fixed air-tight into the cask: of course, all the joints in the apparatus must be air-tight. Supposing the whole to be thus arranged, and the clamp E to be opened to a suitable extent, the carbonic acid gas generated in the bottle A would pass into the cask as fast as it was required; and when the cask was sufficiently supplied, the whole apparatus would become quiescent. When using such an apparatus in connection with a cask from which wine escapes very slowly, the clamp E of the gas generator must be screwed up pretty closely; but when using it with a cask from which wine is to be frequently and rapidly drawn, the clamp E must be left sufficiently open, and the whole apparatus must be sufficiently large and powerful to supply a full and rapid current of gas. In all cases, when the cask is supplied with as much gas as it requires, the passage of the gas ceases, the acid is driven back, and the whole comes to rest. In this manner a constant pressure of carbonic acid gas is kept up in the cask, and the entrance of atmospheric air, with its free oxygen, is prevented.



212. Letters A, B, in Fig. 29, represent another form of apparatus for the same use as the apparatus represented by Fig. 28. The rest of Fig. 29 is adapted for other purposes. In using this apparatus, the flint-stones and the marble are put into the bottle A, which should be nearly filled with marble. The hydrochloric acid is put into the pear-shaped vessel B. The point of the tube *f* must go down among the gravel, below the marble. The stopper is removed from the vessel B.

The clamp *e* and tube *g* are joined directly to the tube *c*, and the intermediate parts *d* C are removed. The action of the apparatus is as follows: When the clamp *e* is closed, the gas accumulates in the bottle A, and drives the acid up the tube *f* into the flask B. When the clamp *e* is open, gas escapes there from the bottle A, and the acid descends from B into A, to renew the supply of gas. When connected with a wine-cask, the action would resemble that of the apparatus Fig. 28, as already fully explained.



30.

213. Fig. 30, letters A, B, C, *d*, represents another form of gas generator for this purpose. This kind is formed of salt-glazed stoneware, and can be made of any required size. That part of the figure marked *e f g* is for another purpose. The marble for supplying the carbonic acid gas is put into the bell-jar C, which is provided with a moveable bottom *b*, perforated to permit the acid to get into it. The acid is put into the outer jar A B. The gas escapes from the bell jar by the tube marked *c*, and the quantity of it is regulated by the stopcock *d*, or by a clamp fixed on a caoutchouc tube in its place. The apparatus is put into connection with the wine-cask by a tube fixed in the cask, and connected with the stopcock *d*. When the passage of the gas is stopped, the gas collects in the bell jar C, and drives the acid

into the outer jar A. When the gas is suffered to escape, the acid passes from the outer jar A, into the bell jar C, and produces a fresh supply.

Any instrument constructed on this principle can evidently be used to keep a constant pressure of carbonic acid gas in a partly-empty wine cask, and so prevent the access of air and oxygen, and the mischief which they occasion.

214. The Acidity of Wines and Must, compared with that of Solutions containing specific weights of Crystallised Tartaric Acid in a gallon :—

The marginal numbers are Grains of Acid in a gallon.

100 } 200 }	Wines with less than 300 grains are too flat for agreeable drink.	
250	Port Wines and others very strong in alcohol can have this degree of acidity.	
300 } 400 } 450 }	Light Wines of good quality contain between 300 and 450 grains of acid in a gallon.	
500 }	Wines with between 500 and 700 grains are unpleasantly acid.	
600 } 700 }	Wines with above 700 grains, that is to say, which contain above 1 per cent. of acid, are undrinkably sour.	
800 } 900 } 1000 } 1100 } 1200 } 1300 } 1400 }	In cold seasons the juice of Grapes can have these degrees of acidity, with only 12 to 14 per cent. of sugar. Such juice makes weak and sour wines.	(These juices can be corrected before fermentation by dilution with water till the acid is under 500 grains, and by the addition of sugar till the whole sugar amounts to 20 per cent.
1500 } 1600 } 1700 } 1800 } 1900 } 2000 } 2100 }	The juice of currants and other fruits can occur of these degrees of acidity, and with sugar as low as 5 or 6 per cent.	(Such juice must be diluted before fermentation till the acid is under 500 grains, and the sugar must be increased to 25 per cent.

BLENDING AND FORTIFYING OF WINES AND SPIRITS.

215. TABLE VII., page 40, is described as a Table "for the DILUTION of Spirits, and for the Valuation of Proof Spirit according to Sikes." But the numbers contained in that Table can also be used in calculating the proportions in which spirits, or wines, should be *mixed*, when the purpose is to RAISE some liquors from low degrees to determine higher degrees by the addition of more concentrated liquors.

Let

m = the EQUIVALENT VOLUME of the desired mixture corresponding to its DEGREE as expressed in Table VII.

w = the Equivalent Volume of the Weak liquor, the strength of which is to be raised.

s = the Equivalent Volume of the Strong liquor that is to be used to raise the Degree of the Weak liquor.

W = the mixing proportion by volume of the Weak liquor.

S = the mixing proportion by volume of the Strong liquor.

Then, the calculations to be made are expressed in the following equations:—

$$\begin{aligned}(m - s) \times w &= W \\ (w - m) \times s &= S.\end{aligned}$$

That is to say:—

To find W , the mixing proportion by volume of the weak liquor, take m , the equivalent volume of the desired mixture, and we deduct from it s , the equivalent volume of the strong liquor, and then we multiply the residue by w , the equivalent volume of the weak liquor. The product is W .

And to find S , the mixing proportion by volume of the strong liquor, we take w , the equivalent volume of the weak liquor, and we deduct from it m , the equivalent volume of the desired mixture, and then we multiply the residue by s , the equivalent volume of the strong liquor. The product is S .

EXAMPLE 1.

A liquor at 10° of Sikes is to be raised to 15° by the addition of a liquor at 20° .

The Equivalent Volumes that correspond to the given degrees are to be taken from Table VII.

Degree	$m = 15^\circ$	$s = 20^\circ$	$w = 10^\circ$
Equivalent volume	666.67	500.00	1000.00
Deduct	500.00		666.67
	<hr/>		<hr/>
Remainder	166.67		333.33
Multiply by	1000.00		500.00

Product 166670.0000 = W . 166665.0000 = S .

The products show that the liquors at 10° and 20° must be mixed in equal volumes to produce the mixture of 15° .

EXAMPLE 2.

A wine at 25° of Sikes is to be raised to 40° by the addition of spirit at 160° .

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Degree	$m = 40^{\circ}$	$s = 160^{\circ}$	$w = 25^{\circ}$
Equivalent volume	250.0	62.5	400.0
Deduct	62.5		250.0
	<hr/>		<hr/>
Remainder	187.5		150.0
Multiply by	400.0		62.5
	<hr/>		<hr/>
Product	75000.00 = W.		9375.00 = S.
	$\frac{75000}{9375} = 8.$		

Result.—Eight volumes of the wine at 25° mixed with 1 volume of the spirit at 160° gives 9 volumes of the fortified mixture at 40° .

PROOF.

800 volumes of w at 25° contain	200.0
100 volumes of s at 160° contain	160.0
900 volumes of mixture at 40° contain	360.0
$\frac{1}{8}$ part = 100 volumes	contain 40°

EXPERIMENTAL DETERMINATION OF THE QUANTITY OF ALCOHOL IN SPIRITS.

Alcoholic liquors are presented for examination under two forms. The first description contain alcohol and water only: the second contain alcohol, water, sugar, acids, tannin, and certain volatile oils. The first are called spirits, or spirits of wine: the second bear the well-known names of Brandy, Rum, Gin, Whiskey, &c.

A. SPIRITS OF WINE.

216. To determine the quantity of alcohol contained in spirits of wine, we have only to take its specific gravity, and then ascertain its value by means of the Tables and Formulæ given between pages 20 and 50 in this work. The instrument used to determine the specific gravity may be that of Sikes, or of Gay-Lussac, or of Tralles; or it may be the weighing-bottle. It does not much signify which of these instruments is made use of; because the harmony of alcoholometers, given at the pages referred to, enable us readily to transform the indications given by any one of these instruments into indications that correspond with any other.

Pure spirits are distinguished from mixed spirits by leaving no residue when evaporated to dryness; and by well-known differences in taste and odour.

B. MIXED SPIRITS.

217. MIXED SPIRITS must be treated as WINES. The acid and sugar which they contain must be determined by the processes that are used to determine the quantities of those substances in wines. The alcohol must be separated by distillation, and tested in the same manner as alcohol distilled from wine. Besides these constituents, it would be useful to determine the quantity of tannin, especially in brandy, but I do not know a satisfactory test for it.

I give the following details of the experiments made with the four mixed spirits, Nos. 42 to 45, in Tables I. and II. :—

218. GOOD BRANDY.—100 septems weighed 654·10 grains. Specific gravity ·9344. 100 septems took $\frac{1}{2}$ septem of ammonia test for neutralization, indicating $2\frac{1}{2}$ grains of tartaric acid in a gallon. The distillate from 50 septems of brandy, diluted to 100 septems, weighed 678·03 grains. This number is not contained in Table IV., but a calculation by interpolation gave 303·40 grains, col. 5, Table I., equal to 46·38 per cent., col. 3, Table II. The copper test showed that

29.4 septems of the brandy contained $\frac{1}{2}$ grain of sugar, which gave 170 grains per gallon, and .26 per cent. After determining the grape-sugar, the brandy was tested for cane-sugar, by the process given in § 152, but none was found.

219. PUBLIC-HOUSE BRANDY.—Tried like the good brandy, with the results quoted in Tables I. and II., No. 43. ~~It contained no sugar, or barely a trace.~~ The trial for cane-sugar gave none. This brandy contained an enormous quantity of tannin, so that when mixed with a solution of iron salt, it became almost like ink. The tannin, in company with some mucilaginous matter, impeded the action of the copper test. This brandy was evidently not a *distilled* spirit, and I was puzzled by it, till I read in a German book the following instructions for manufacturing Cognac:—

“Take of Acetic Ether $\frac{3}{4}$ lb.

Spirit of Nitric Ether $\frac{1}{2}$ lb.

French Wine 8 quarts.

Oak-bark Tincture (made with $\frac{1}{2}$ lb. of oak bark and $\frac{1}{2}$ quart of spirit) $\frac{1}{2}$ quart.

Purified Spirits, so much as to bring the whole to 150 quarts of 54 per cent. by Tralles.

“This mixture, after long cellaring, is very similar to real Cognac in taste and odour.”

Here we have a tincture of oak-bark, mixed with a couple of ethers commonly used as physic, passed off as Cognac. This sort of sophistication is evidently becoming an ordinary commercial practice. I procured lately a bottle of brandy from a large “Grocer and Wine Merchant.” It contained very common spirit, which tasted powerfully of fusel oil; a quantity of this oak saw-dust liquor, and an abundance of sugar.

220. RUM.—Examined for alcohol, acid, grape-sugar, and cane-sugar, in the same manner as the brandy. The results are stated at No. 44 in Tables I. and II.

221. GIN.—Tried for alcohol, with the result given at No. 45 in Tables I. and II.

Gin was found to differ essentially from the rum and brandies in the following particulars:—It contained not a trace of acid. It was very sweet; but when tried with the copper test, gave no result. It was then treated for cane-juice by the process described at § 152, page 82, being first diluted with water from 1 volume to 5 volumes. As shown by the Tables, it was then found to contain a considerable quantity of cane-sugar.

It is worthy of notice, that this cane-sugar was found in a liquor that was quite free from acid; whereas, in all liquors, both wines and spirits, that contained free acids, the sugar detected was always in the state of grape-sugar.

TABLE XVI.—COMPARISON of the IMPORT DUTIES on WINES and SPIRITS, reckoned PER GALLON, for DEGREES of STRENGTH verified by SIKES's Hydrometer.

1	2		3	4		1	2		3	4			
Degree according to Sikes.	Present Duty on Spirits.		Present Duty on Wines.	Suggested Duty on Wines.		Degree according to Sikes.	Present Duty on Spirits.		Present Duty on Wines.	Suggested Duty on Wines.			
0	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.	
10	1	0 $\frac{1}{2}$	1	0	0	6	31	3	2 $\frac{3}{4}$	2	6	1	9
11	1	1 $\frac{1}{2}$	1	0	0	6	32	3	4	2	6	1	10 $\frac{1}{2}$
12	1	3	1	0	0	6	33	3	5 $\frac{1}{4}$	2	6	2	0
13	1	4 $\frac{1}{4}$	1	0	0	6	34	3	6 $\frac{1}{2}$	2	6	2	1 $\frac{1}{2}$
14	1	5 $\frac{1}{2}$	1	0	0	6	35	3	7 $\frac{1}{4}$	2	6	2	3
15	1	6 $\frac{1}{4}$	1	0	0	6	36	3	9	2	6	2	4 $\frac{1}{2}$
16	1	8	1	0	1	0	37	3	10 $\frac{1}{4}$	2	6	2	6
17	1	9 $\frac{1}{4}$	1	0	1	0	38	3	11 $\frac{1}{2}$	2	6	2	7 $\frac{1}{2}$
18	1	10 $\frac{1}{2}$	1	0	1	0	39	4	0 $\frac{1}{4}$	2	6	2	9
19	1	11 $\frac{1}{4}$	1	0	1	0	40	4	2	2	6	2	10 $\frac{1}{2}$
20	2	1	1	0	1	0	41	4	3 $\frac{1}{4}$	2	6	3	0
21	2	2 $\frac{1}{4}$	1	0	1	0	42	4	4 $\frac{1}{2}$	2	9	3	3
22	2	3 $\frac{1}{2}$	1	0	1	0	43	4	5 $\frac{1}{4}$	3	0	3	6
23	2	4 $\frac{1}{4}$	1	0	1	0	44	4	7	3	3	3	9
24	2	6	1	0	1	0	45	4	8 $\frac{1}{4}$	3	6	4	0
25	2	7 $\frac{1}{4}$	1	0	1	0	46	4	9 $\frac{1}{2}$	3	9	4	3
26	2	8 $\frac{1}{2}$	2	6	1	1 $\frac{1}{2}$	47	4	10 $\frac{1}{4}$	4	0	4	6
27	2	9 $\frac{1}{4}$	2	6	1	3	48	5	0	4	3	4	9
28	2	11	2	6	1	4 $\frac{1}{2}$	49	5	1 $\frac{1}{4}$	4	6	5	0
29	3	0 $\frac{1}{4}$	2	6	1	6	50	5	2 $\frac{1}{4}$	4	9	5	3
30	3	1 $\frac{1}{2}$	2	6	1	7 $\frac{1}{2}$	51	5	3 $\frac{1}{4}$	5	0	5	6
1	2		3		4		1	2	3		4		

The duty on Spirits is reckoned at 10s. 5d. per imperial gallon of Proof Spirit. Dividing Proof Spirit into 100°, this rate of duty is 1 $\frac{1}{4}$ d. per gallon for every degree of Sikes.

One degree (1°) of Sikes is equivalent to the following quantities:—

- To the hundredth part by measure of a gallon of Proof Spirit.
- To 643·89 grains by weight of Proof Spirit in a gallon.
- To 317·05 grains by weight of Absolute Alcohol in a gallon.
- To 0·5706 per cent. by volume of Absolute Alcohol.

APPENDIX.

CATALOGUE OF THE APPARATUS AND TEST LIQUORS
REQUIRED FOR THE CHEMICAL TESTING OF WINES
AND SPIRITS.

A. FOR WEIGHING LIQUIDS.

	£.	s.	d.
1. Balance, Fig. 2. In a mahogany box. Beam $10\frac{1}{2}$ inches long, Pans $2\frac{1}{2}$ inches wide. With 1000 grains, it shows $\frac{1}{80}$ grain; with 4 ounces, it shows $\frac{1}{36}$ grain	1	18	-
2. Set of Grain Weights in a box containing 600, 300, 200, 100; 60, 30, 20, 10 grains in brass; and 6, 3, 2, 1; .6, .3, .2, .1; .06, .03, .02, .01 grain in platinum, with two riders of .1 grain	1	5	-
3. Standard Centigallon Measure, Fig. 1. Used also as a Weighing Bottle for estimating specific gravities	-	3	6
4. Counterpoise for the Specific Gravity Bottle when weighted with 680 grains, made of brass, with a wooden case	-	2	-
5. Pipette for Filling the Specific Gravity Bottle with liquid. (See No. 14.)	-	-	-
6. Narrow Glass Tube, to adjust the measure in the bottle. (See No. 32.)	-	-	-
7. Thermometer cased in glass, Fig. 4, $\frac{3}{8}$ inch diameter. Scale on Milk-glass, up to 350° Fahr.	-	5	-

B. FOR DISTILLATIONS.

8. Japanned Copper Condenser with Glass Condensing Tube, a Glass Retort of the capacity of 4 fluid ounces or 250 septems, and a pair of caoutchouc collars to fix the whole together as represented by Fig. 7. With an extra glass condensing tube and two extra glass retorts	-	18	-
9. Glass Spirit Lamp with rack to regulate the flame, Fig. 10	-	2	6

	£.	s.	d.
10. Plaited Cotton Wick for the Lamp, 1 yard	-	-	6
11. If coal gas is available, it is better to omit Nos. 9 and 10, and use a Gas Burner, such as is represented by Fig. 9, the price of which is 2s. 6d.			
12. Stoneware Cylinder to put around the lamp or gas-burner, E, Fig. 7.	-	1	-
13. Iron trellis top for this furnace cylinder, d, Fig. 7. <i>Two Pieces</i>	-	-	4
14. Pipette to measure 50 septems of wine for distillation, Fig. 12. <i>Two Copies</i>	-	2	6
15. Long Narrow Funnel for use in filling the Retort, Fig. 11	-	-	3
16. Caustic Soda Solution of 20° in a 6-ounce bottle	-	1	3
17. Tannin in powder, $\frac{1}{2}$ -ounce in a bottle	-	1	-
18. Spoon for putting tannin into the Retort, Fig. 15	-	1	-
19. Set of Four Beaked Tumblers for use with liquids, Fig. 13	-	2	4
20. Blue Litmus Paper for testing the acidity of wines. (See No. 33.)			2d.
21. Glass Stirrers for mixing liquors. (See No. 28.)			1d.

C. ESTIMATION OF FREE ACID.

22. Mohr's Burette, A, Fig. 16, with pinchcock and jet, a and b. Graduated into 100 septems and $\frac{1}{4}$ ths of septem	-	6	-
23. Mahogany Support for the Burette, B, Fig. 16	-	5	6
24. Marble to close the Burette, c, Fig. 16			
25. Pair of Mixing Jars, pint size, C and D, Fig. 16. Graduated into spaces of 250, 500, and 1000 septems	-	4	6
26. Pair of Mixing Jars, half-pint size, form of C, Fig. 16, but not graduated	-	1	8
27. Pair of White-glazed China Slabs, E E, Fig. 16, to throw up the colours produced in the mixing jars	-	2	-
28. Glass Stirrers, F, Fig. 16, 6 and 9 inches long, 3 of each	-	-	4
29. Pipette to deliver 10 Septems, Fig. 17	-	-	9
30. Pipette to deliver 25 septems	-	1	-
31. Pipette graduated to deliver 10 septems in $\frac{1}{2}$ septems	-	1	6
32. Narrow Plain Tubes or Pipettes for regulating measures at a mark, or transferring small portions of liquid. <i>Three Copies</i>	-	-	6
33. Box of Books of Red and Blue Litmus Papers	-	1	-
34. Brush with long Handle to clean the Burette, No. 22	-	-	6

	£.	s.	d.
35. Tube graduated to show 50 septems, for collecting volatile acids in fractional distillations, Fig. 20. <i>Two Copies</i>	-	4	-
36. Standard Ammonia for testing free acid; strength, $\frac{3}{4}^{\circ}$, 1 pint in a bottle <i>Half-gallon in a bottle, 6s.</i>	-	2	-
37. Standard Nitric Acid of equal strength with the Ammonia, $\frac{3}{4}^{\circ}$, 1 pint in a bottle <i>Half-gallon in a bottle, 6s.</i>	-	2	-
38. Tartaric Acid, pure crystallized, to prepare standard acid of 500 grains per gallon, 2 ounces in a stoppered bottle	-	1	6
39. Flask to contain 500 septems, Fig. 18. (See No. 51.) 1s. 9d.			
40. Logwood in powder, to prepare hematine tincture, in 6-ounce stoppered glass-bottle	-	1	-
41. Glass Flask, 4-ounce size, in which to prepare a decoction of logwood. <i>Two Copies</i>	-	-	6
42. Pipette Bottle, 6-ounce size, to contain the hematine tincture	-	1	-
<i>The next three articles are only of use in the preparation of the two tests Nos. 36 and 37, and are not required by those who purchase the solutions prepared.</i>			
43. Test Mixer, Fig. 19, capacity 2 decigallons, graduated into 100 parts			9s.
44. Pure Ammonia, strong, 40° , 1 pint in a bottle			1s. 8d.
45. Pure Nitric Acid, strong, 30° , 1 pint in a bottle			3s. 4d.

D. ESTIMATION OF SUGAR.

46. The principal apparatus represented by Fig. 21 has been for the most part already priced in detail:— The Burette A is No. 22 The Support B is No. 23 The Furnace D is Nos. 9, 10, and 12 Two Pieces, 47 and 48, are not yet cited.			6s. 5s. 6d. 4s.
47. Porcelain Evaporating Basin, C, Fig. 21, $4\frac{1}{2}$ inches in diameter	-	1	-
48. Iron Ring Top to adapt the Evaporating Basin to the Lamp Cylinder	-	-	4
49. Measuring flask, like Fig. 18, to contain 100 septems	-	1	-
50. Measuring Flask to contain 200 septems	-	1	3

	£.	s.	d.
51. Measuring Flask to contain 500 septems	-	1	9
52. Glass Funnel for filtrations, 3 inches diameter	-	-	3
53. Box with 200 cut filters to fit the funnel	-	2	3
54. Washing Bottle with two tubes	-	1	6
55. Copper Test for Sugar, Solution A and Solution B, one pint of each, in two bottles	-	5	-
56. Carbonate of Soda Solution in a 6-ounce bottle	-	1	-
57. Slaked Lime in 6-ounce bottle	-	1	-
58. Alum Liquor ditto	-	-	9
59. Sub-acetate of Lead ditto	-	1	6

E. ESTIMATION OF SOLID RESIDUE.

60. The apparatus is represented by Fig. 22, the following portions of which have been already cited:— The Furnace, A B. (See Nos. 9, 10, 12.)	4s.		
The Ring Top, <i>a</i> . (See No. 48.)	4d.		
The Thermometer. (See No. 7.)	5s.		
61. Porcelain Crucible, $2\frac{1}{4}$ inch diameter, <i>b</i> , Fig. 22, with cover. <i>Two Copies</i>	-	1	8
62. Clay Evaporator, with conical perforation, <i>c</i>	-	1	4
63. Hot-air Bath for drying residues at 230° Fahr., con- sisting of a round clay plate grooved on the sur- face <i>d d</i> , a glass receiver <i>e</i> , a copper tripod to support the crucible, and a perforated cork with an open glass tube, and a hole for the thermometer, No. 7	<i>The Set</i>	-	2 6
64. Cooling Apparatus, Fig. 23, consisting of a glass cylinder with ground edges, a ground glass cover, and a copper tripod to support the crucible	-	2	0
65. Pair of Crucible Tongs, bright iron	-	1	6
66. Slip of Platinum Foil, Fig. 26	-	1	-

F. ESTIMATION OF ASH.

67. Argand Spirit Lamp and Support, Fig. 24, with the addition of a branch sustaining a crucible jacket, like that represented by <i>a</i> , <i>b</i> , Fig. 25, with one dozen cotton wicks	-	19	-
68. When coal gas is available, the Argand Spirit Lamp, No. 67, is omitted, in exchange for the following apparatus:—			
69. Large Rose Gas-burner, with iron stand and crucible jacket as represented by Fig. 25, with the addition of a branch bearing a funnel-holder			10s.

	£.	s.	d.
70. Six Feet of Vulcanized Tube, $\frac{3}{8}$ inch bore, to use with the gas-burners, Nos. 11 and 69			5s.

SUMMARY.

The Complete Set of Apparatus and Test Liquors, as above enumerated	9	9	-
Articles for preparing Test Liquors, Nos. 43, 44, 45, cost, together, 14s. <i>extra</i> .			
Those who already possess a good Balance and Weights will not require the articles Nos. 1 and 2, which reduces the cost of the set of apparatus from £9 9s. to	6	6	-

DISTILLED WATER.

The Operation of Wine Testing demands a liberal supply of distilled water, with which to make the prescribed dilutions, and also for the washing of the vessels.

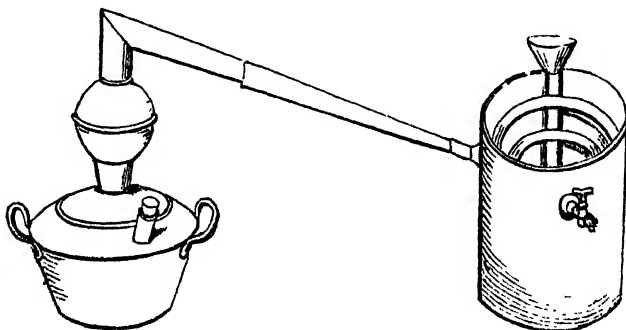


Fig. 31 represents one of the simplest forms of still for preparing pure water. It is made of tin plate, of the capacity of one gallon. It can be used over a common kitchen fire. The price of it is 14s. In my work entitled "CHEMICAL HANDICRAFT," I have described a great variety of stills for use with gas as well as with charcoal or coke.

*The Apparatus and Graduated Test
Liquors described in the preceding List
are supplied by John J. Griffin and
Sons, 22, Garrick Street, W. C.,
London.*

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